SS Physics Curriculum- Compulsory Part (for students taking 2016 and after 2016 HKDSE)

Heat and Gases (23 hours)

Topics	Content	Notes for teachers
(a) Temperature, heat and internal energy		
temperature and thermometers	• realise temperature as the degree of hotness of an object • interpret temperature as a quantity associated with the average kinetic energy due to the random motion of molecules in a system • explain the use of temperature-dependent properties in measuring temperature • define and use degree Celsius as a unit of temperature	• Same treatment as in HKCEE • Basic principle of how temperature dependent properties can be used for measuring temperature *is required* • Calibrating a thermometer by plotting a linear graph *is required* • The detailed structure and facts (e.g. working range, suitability) of thermometers *are not required*
heat and internal energy	• realise that heat is the energy transferred as a result of the temperature difference between two objects • describe the effect of mass, temperature and state of matter on the internal energy of a system • relate internal energy to the sum of the kinetic energy of random motion and the potential energy of molecules in the system	• Same treatment as in HKCEE
heat capacity and specific heat capacity	• define heat capacity as $C = \frac{Q}{\Delta T}$ and specific heat capacity as $c = \frac{Q}{m\Delta T}$ • determine the specific heat capacity of a substance • discuss the practical importance of the high specific heat capacity of water • solve problems involving heat capacity and specific heat capacity	• Same treatment as in HKCEE
(b) Transfer processes		
conduction, convection and radiation	• identify the means of energy transfer in terms of conduction, convection and radiation • interpret energy transfer by conduction in terms of molecular motion • realise the emission of infra-red radiation by hot objects • determine the factors affecting the emission and absorption of radiation	• Same treatment as in HKCEE • Molecular interpretation of convection *is not required* • Factors affecting the rate of conduction *are not required*

Topics	Content	Notes for teachers
(c) Change of state		
melting and freezing, boiling and condensing	• state the three states of matter • determine the melting point and boiling point	• Same treatment as in HKCEE
latent heat	• realise latent heat as the energy transferred during the change of state without temperature change • interpret latent heat in terms of the change of potential energy of the molecules during a change of state • define specific latent heat of fusion as $\ell_f = \frac{Q}{m}$ • define specific latent heat of vaporization as $\ell_v = \frac{Q}{m}$ • solve problems involving latent heat	• Same treatment as in HKCEE
evaporation	• realise the occurrence of evaporation below boiling point • explain the cooling effect of evaporation • discuss the factors affecting rate of evaporation • explain evaporation in terms of molecular motion	• Same treatment as in HKCEE • Qualitative explanation of evaporation and its cooling effect in terms of molecular motion *are required* • Interpreting the factors affecting the rate of evaporation in terms of molecular motion *is not required*
(d) Gases		
general gas law	• realise the existence of gas pressure • verify Boyle's law • determine pressure-temperature and volume-temperature relationships of a gas • determine absolute zero by the extrapolation of pressure-temperature or volume-temperature relationships • use kelvin as a unit of temperature • combine the three relationships (*p*-*V*, *p*-*T* and *V*-*T*) of a gas to obtain the relationship $\frac{pV}{T} = \text{constant}$ • apply the general gas law $pV = nRT$ to solve problems	• Volume-Temperature and Pressure-Temperature relationships of a gas are used instead of Charles' law and Pressure law • Describing experiments to verify Boyle's law, *V*-*T* and *p*-*T* relationships of a gas *are expected* • Avogadro's law *is not required* • Critical temperature *is not required* • Heating and work done on gas (1st law of thermodynamics) *are not required* • *pV* diagrams *are required* • Thermodynamic processes and cycles (e.g. isothermal, isobaric and adiabatic) *are not required* • Mole, molar mass and Avogadro's number *are required* Mathematics skills involved: Compulsory Part in Math • 6. Variations • 12. Equations of straight lines and circles

Topics	Content	Notes for teachers
kinetic theory	• realise the random motion of molecules in a gas • realise the gas pressure resulted from molecular bombardment • interpret gas expansion in terms of molecular motion • state the assumptions of the kinetic model of an ideal gas • realize $pV = \frac{Nm\overline{C^2}}{3}$ that connects microscopic and macroscopic quantities of an ideal gas and solve problems • interpret temperature of an ideal gas using $K.E._{average} = \frac{3RT}{2N_A}$ • realise the condition that at high temperature and low pressure a real gas behaves as an ideal gas • solve problems involving kinetic theory	• Stating that at high temperature and low pressure a real gas behaves as an ideal gas *is required* • Detailed microscopic explanation for the condition of a real gas to show the behaviour of an ideal gas *is not required* • Derivation of $pV = \frac{Nm\overline{C^2}}{3}$ *is not required* • Comparing $pV = \frac{Nm\overline{C^2}}{3}$ with $pV = nRT$ and deducing that the total kinetic energy of one mole of a monatomic gas is given by $\frac{3RT}{2}$ and hence the average kinetic energy of the monatomic gas molecule is $\frac{3}{2}\left(\frac{R}{N_A}\right)T$, and T is proportional to the average kinetic energy *are required.* • Boltzmann constant *k is not required* ☺ *Momentum and kinetic energy are introduced in "Force and Motion"*

Force and Motion (50 hours)

Topics	Content	Notes for teachers
(a) Position and movement		
position, distance and displacement	• describe the change of position of objects in terms of distance and displacement • present information on displacement-time graphs for moving objects	• Combining percentage errors *is not required* ☺ Vernier caliper and micrometer could be used as instruments in practical work Mathematics skills involved: Compulsory Part in Math • 2. Functions and graphs • 9. More about graphs of functions • Calculus is not expected
scalars and vectors	• distinguish between scalar and vector quantities • use scalars and vectors to represent physical quantities	*Mathematics skills involved - Module 2 (Algebra and Calculus) in Math* • 15. Introduction to vectors • Teachers are expected to introduce the necessary basic ideas of vectors
speed and velocity	• define average speed as the distance travelled in a given period of time and average velocity as the displacement changed in a period of time • distinguish between instantaneous and average speed/velocity • describe the motion of objects in terms of speed and velocity • present information on velocity-time graphs for moving objects • use displacement-time and velocity-time graphs to determine the displacement and velocity of objects	• Relative velocity *is not required* Mathematics skills involved: Compulsory Part in Math • 12. Equations of straight lines and circles
uniform motion	• interpret the uniform motion of objects using algebraic and graphical methods • solve problems involving displacement, time and velocity	
acceleration	• define acceleration as the rate of change of velocity • use velocity-time graphs to determine the acceleration of objects in uniformly accelerated motion • present information on acceleration-time graphs for moving objects	

☺ Learning and teaching strategies for reference only.

SS Physics Curriculum- Compulsory Part (for students taking 2016 and after 2016 HKDSE)

Topics	Content	Notes for teachers
equations of uniformly accelerated motion	• derive equations of uniformly accelerated motion $v = u + at$ $s = \frac{1}{2}(u + v)t$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ • solve problems involving objects in uniformly accelerated motion	Mathematics skills involved: Compulsory Part in Math • 1. Quadratic equations in one unknown
vertical motion under gravity	• examine the motion of free-falling objects experimentally and estimate the acceleration due to gravity • present graphically information on vertical motions under gravity • apply equations of uniformly accelerated motion to solve problems involving objects in vertical motion • describe the effect of air resistance on the motion of objects falling under gravity	• Dependence of air resistance on mass, size and shape of objects *is not required*
(b) Force and motion		
Newton's First Law of motion	• describe the meaning of inertia and its relationship to mass • state Newton's First Law of motion and use it to explain situations in which objects are at rest or in uniform motion • understand friction as a force opposing motion/tendency of motion	• Concepts and formulae of kinetic friction and static friction *are not required*
addition and resolution of forces	• find the vector sum of coplanar forces graphically and algebraically • resolve a force graphically and algebraically into components along two mutually perpendicular directions	Mathematics skills involved: Compulsory Part in Math • 13. More about trigonometry
Newton's Second Law of motion	• describe the effect of a net force on the speed and/or direction of motion of an object • state Newton's Second Law of motion and verify $F = ma$ experimentally • use newton as a unit of force • use free-body diagrams to show the forces acting on objects • determine the net force acting on object(s) • apply Newton's Second Law of motion to solve problems involving motion in one dimension	• Solving problems involving two-body or many-body systems *is expected*
Newton's Third Law of motion	• realise forces acting in pairs • state Newton's Third Law of motion and identify action and reaction pair of forces	

Topics	**Content**	**Notes for teachers**
mass and weight	• distinguish between mass and weight • realise the relationship between mass and weight	
moment of a force	• define moment of a force as the product of the force and its perpendicular distance from the pivot • discuss the uses of torques and couples • state the conditions for equilibrium of forces acting on a rigid body and solve problems involving a fixed pivot • interpret the centre of gravity and determine it experimentally	• Same treatment as in HKCEE • Solving problems involving non-perpendicular forces *is expected* • Stability of an object (neutral, unstable and stable equilibrium in relation to the position of C.G.) *is not required* ☺ Suitable examples should be used to help students understand the concept of moment of a force
(c) Projectile motion	• describe the shape of the path taken by a projectile launched at an angle of projection • understand the independence of horizontal and vertical motions • solve problems involving projectile motion	• Resolving vector quantities into horizontal and vertical components and solving problems by considering the x and y directions separately *are required* • Deriving the equations for the range, time of flight and maximum height *is not required* • Deriving the equation $y(x)$ for the parabolic trajectory *is not required* • Quantitative treatment of air resistance on projectile motion *is not required*
(d) Work, energy and power		
mechanical work	• interpret mechanical work as a way of energy transfer • define mechanical work done $W = Fs\cos\theta$ • solve problems involving mechanical work	
gravitational potential energy (P.E.)	• state that gravitational potential energy is the energy possessed by an object due to its position under gravity • derive $P.E. = mgh$ • solve problems involving gravitational potential energy	
kinetic energy (K.E.)	• state that kinetic energy is the energy possessed by an object due to its motion • derive $K.E. = \frac{1}{2}mv^2$ • solve problems involving kinetic energy	
law of conservation of energy in a closed system	• state the law of conservation of energy • discuss the inter-conversion of P.E. and K.E. with consideration of energy loss • solve problems involving conservation of energy	• The concepts of energy being stored when spring/elastic cord is extended/compressed *are required* and that the amount of energy stored increases with the extension/compression *are also assumed* • The equation of elastic $P.E. = \frac{1}{2}kx^2$ *is not required* • Solving problems involving 2D motions (e.g. projectile motion) *is expected*
power	• define power as the rate of energy transfer • apply $P = \dfrac{W}{t}$ to solve problems	• The use of equation $P = Fv$ *is expected*

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Topics	**Content**	**Notes for teachers**
(e) Momentum		
linear momentum	• realise momentum as a quantity of motion of an object and define momentum $p = mv$	
change in momentum and net force	• understand that a net force acting on an object for a period of time results a change in momentum • interpret force as the rate of change of momentum (Newton's Second Law of motion)	• "Change in momentum" is used instead of the term "impulse" • Interpretation of *F-t* graph *is expected*
law of conservation of momentum	• state the law of conservation of momentum and relate it to Newton's Third Law of motion • distinguish between elastic and inelastic collisions • solve problems involving momentum in one dimension	• Deriving the law of conservation of momentum from Newton's laws of motion *is expected* • Condition of right-angle fork collision (same mass, elastic) and its applications (e.g. collision between α-particle and Helium gas atom in cloud chamber) *are expected* • Mathematical proof of the right-angle fork collision *is not required* • The extension of right-angle fork collision to cases of unequal masses or with K.E. loss *is not required*
(f) Uniform circular motion	• define angular velocity as the rate of change of angular displacement and relate it to linear velocity • state centripetal acceleration $a = \frac{v^2}{r}$ and apply it to solve problems involving uniform circular motion • realise the resultant force pointing towards the centre of uniform circular motion	• Identifying the centripetal force responsible for the object to undergo uniform circular motion *is required* • Non-uniform circular motion (e.g. looping the loop, roller coaster and vertical motion of a bucket of water) *is not required* • Overturning of vehicles (involving moment) *is not required* • Centrifuge *is not required* • Discussing the motion and energy of a satellite with a K.E. loss *is not required* ☺ Suitable examples should be selected to illustrate the concept of uniform circular motion Mathematics skills involved: Compulsory Part in Math • 12. Basic properties of circles
(g) Gravitation	• state Newton's law of universal gravitation $F = \frac{GMm}{r^2}$ • define gravitational field strength as force per unit mass • determine the gravitational field strength at a point above a planet • determine the velocity of an object in a circular orbit • solve problems involving gravitation	• Gravitational field within the Earth / planet *is not required* • Addition of gravitational field strength due to two or more object *is not required* • Kepler's laws *are not required* • Escape velocity *is not required* • Paths of object being projected with different speeds *are not required*

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Wave Motion (47 hours)

Topics	Content	Notes for teachers
(a) Nature and properties of waves		
nature of waves	• interpret wave motion in terms of oscillation • realise waves as transmitting energy without transferring matter	• Huygen's principle *is not required*
wave motion and propagation	• distinguish between transverse and longitudinal waves • describe wave motion in terms of waveform, crest, trough, compression, rarefaction, wavefront, phase, displacement, amplitude, period, frequency, wavelength and wave speed • present information on displacement-time and displacement-distance graphs for travelling waves • determine factors affecting the speed of propagation of waves along stretched strings or springs • apply $f = 1 / T$ and $v = f\lambda$ to solve problems	• Direction of motion of medium particles in displacement-distance graphs *is assumed* • Predict the direction of motion of wave, time lags and time leads in displacement-time and displacement-distance graphs • Study phase difference between two sinusoidal waves in simple cases (in-phase and anti-phase) only • Study displacement-time / displacement-position graphs of transverse and longitudinal waves
reflection and refraction	• realise the reflection of waves at a plane barrier/ reflector/ surface • realise the refraction of waves across a plane boundary • examine the change in wave speeds during refraction and define refractive index in terms of wave speeds • draw wavefront diagrams to show reflection and refraction	• Frequency measurement by stroboscope *is not required* • Phase difference between two arbitrary wave particles *is not required* ☺ Ripple tank could be used to demonstrate wave motion and wave properties. ☺ Video Camera and HDMVA could be used to analyse wave motion, and measure wavelength and speed
diffraction and interference	• describe the diffraction of waves through a narrow gap and around a corner • examine the effect of the width of slit on the degree of diffraction • describe the superposition of two pulses • realise the interference of waves • distinguish between constructive and destructive interferences • examine the interference of waves from two coherent sources • determine the conditions for constructive and destructive interferences in terms of path difference • draw wavefront diagrams to show diffraction and interference	• Concept of phase / path difference *is assumed* in double slits interference • Qualitative treatment only for diffraction of wave • Problem on interference plus diffraction *is not required* • Conversion between path difference and phase difference is required for in-phase and anti-phase interference only • Mathematical treatment of superposition *is not required* ☺ Superposition of waves could be demonstrated on a long slinky

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Topics	Content	Notes for teachers
stationary wave (transverse waves only)	• explain the formation of a stationary wave • describe the characteristics of stationary waves	• Relationship between distance between adjacent nodes (anti-nodes) and wavelength *is implied* • Stationary sound (longitudinal) waves *are not required* • Measuring speed of sound using stationary wave *is not required* ☺ A long slinky could be used to demonstrate stationary wave ☺ Vibrations of strings could be used to demonstrate the characteristics of stationary waves
(b) Light		
light in electromagnetic spectrum	• state that the speed of light and electromagnetic waves in a vacuum is 3.0×10^{8} m s^{-1} • state the range of wavelengths for visible light • state the relative positions of visible light and other parts of the electromagnetic spectrum	
reflection of light	• state the laws of reflection • construct images formed by a plane mirror graphically	
refraction of light	• examine the laws of refraction • sketch the path of a ray refracted at a boundary • realize $n = \frac{\sin i}{\sin r}$ as the refractive index of a medium • solve problems involving refraction at a boundary	• Refraction by a prism *is assumed* • Dispersion of white light through a prism *is assumed* from Science (S1-3) Curriculum • Note that refractive index of light of different frequency (colour) is different • Solve problem related to the refractive index of different frequency of light *is required* • General Snell's law *is assumed* Mathematics skills required Compulsory Part in Math • 13. More about Trigonometry
total internal reflection	• examine the conditions for total internal reflection • solve problems involving total internal reflection at a boundary	• Critical angle *is assumed*
formation of images by lenses	• construct images formed by converging and diverging lenses graphically • distinguish between real and virtual images • apply $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ to solve problems for a single thin lens (using the convention "REAL is positive")	• Compound lens system, such as telescope and microscope, *is not required* • Eye defects *are not required* • Using graphical and numerical methods to solve lens problems *is assumed*

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Topics	Content	Notes for teachers
wave nature of light	• point out light as an example of transverse wave • realise diffraction and interference as evidences for the wave nature of light • examine the interference patterns in the Young's double slit experiment • apply $\Delta y = \frac{\lambda D}{a}$ to solve problems • examine the interference patterns in the plane transmission grating • apply $d \sin\theta = n\lambda$ to solve problems	• Air wedge / soap film / adding a thin film to Young's double slits setting / immersing the set-up in water *are not required* • Only principal maxima for Young's double slit experiment *is required* • Derivation of the Young's double slits formula and the diffraction grating formula *is not required* • Interference pattern (fringes) of light *is required* • Numerical problems related to double slits interference *are implied* • Assumptions of the Young's double slits equation *are expected* • Spectrometer is *not required* ☺ Diffraction grating could be used to measure wavelength of a particular monochromatic light
(c) Sound		
wave nature of sound	• realise sound as an example of longitudinal waves • realise that sound can exhibit reflection, refraction, diffraction and interference • realise the need for a medium for sound transmission • compare the general properties of sound waves and those of light waves	• Interference pattern (change of loudness) in sound *is assumed* • Order of magnitude of speed of sound and light *is expected* • Phase method and stationary wave method to measure speed of sound *are not required* ☺ Pulse echo method could be used to estimate the speed of sound
audible frequency range	• determine the audible frequency range • examine the existence of ultrasound beyond the audible frequency range	
musical notes	• compare musical notes using pitch, loudness and quality • relate frequency and amplitude with the pitch and loudness of a note respectively	• Harmonics and overtones *are not required* • Quality of sound in terms of different shapes of waveform only
noise	• represent sound intensity level using the unit decibel • discuss the effects of noise pollution and the importance of acoustic protection	• Typical noise level in daily life *is required* • Noise pollution (very briefly) *is required* • The definition of sound intensity level *is not required* • Relationship between intensity level and amplitude *is not required* • Curves of equal loudness *are not required* • Qualitative treatment of sound intensity level only

SS Physics Curriculum- Compulsory Part (for students taking 2016 and after 2016 HKDSE)

Electricity and Magnetism (48 hours)

Topics	Content	Notes for Teachers
(a) Electrostatics		
electric charges	• examine the evidence for two kinds of charges in nature • realise the attraction and repulsion between charges • state Coulomb's law $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ • interpret charging in terms of electron transfer • solve problems involving forces between point charges	• Concepts of conductor and insulator *are required* • Charging by sharing and induction *is required* • Quantity of charge using the SI unit of charge in C (Coulomb) *is required* • Addition of electric forces due to the interaction of point charges in 2D *is required* ☺ Gold-leaf electroscope could be used as an instrument to demonstrate the presence of electric charges Mathematics skills involved: Module 2 (Algebra and Calculus) • 15. Introduction to Vectors
electric field	• describe the electric field around a point charge and between parallel charged plates • represent an electric field using field lines • explain how charges interact via an electric field • define electric field strength *E* at a point as the force per unit charge on a positive test charge placed at that point • state electric field strength around a point charge by $E = \frac{Q}{4\pi\varepsilon_0 r^2}$ and between parallel plates by $E = \frac{V}{d}$, and solve problems	• Point action *is not required* • Charge distributions on a metal sphere and parallel plates *are required* • Charge distribution on an irregular shaped metal surface *is not required* • Calculating resultant force on a moving charged particle in an electric field is required • Analogy with gravitational field *is not required* • Flame probe *is not required* • Quantitative treatment of electric field strength around point charges and parallel plates *is required* • Note that electric field strength is a vector quantity ☺ Experiments involving a shuttling ball and foil strip could be used to demonstrate electric force and field ☺ Introduce the concept of potential difference *V* in "electrical energy and electromotive force" prior to applying $E = \frac{V}{d}$ to solve problems Mathematics skills involved: Compulsory Part in Math • 12. Equations of straight lines and circles – slope of a straight line
(b) Circuits and domestic electricity		
electric current	• define electric current as the rate of flow of electric charges • state the convention for the direction of electric current	• Same treatment as in HKCEE

Topics	Content	Notes for Teachers
electrical energy and electromotive force	• describe the energy transformations in electric circuits • define the potential difference (p.d.) between two points in a circuit as the electric potential energy converted to other forms per unit charge passing between the points outside the source • define the electromotive force (e.m.f.) of a source as the energy imparted by the source per unit charge passing through it	• Same treatment as in HKCEE
resistance	• define resistance $R = \frac{V}{I}$ • describe the variation of current with applied p.d. in metal wires, electrolytes, filament lamps and diodes • realise Ohm's law as a special case of resistance behaviour • determine the factors affecting the resistance of a wire and define its resistivity $\rho = \frac{RA}{l}$ • describe the effect of temperature on resistance of metals and semiconductors	☺ Demonstration of the variation of current with applied p.d. in various conductors and circuit elements (metals, a filament bulb, electrolyte, thermistors and diodes) is encouraged
series and parallel circuits	• compare series and parallel circuits in terms of p.d. across the components of each circuit and the current through them • derive the resistance combinations in series and parallel $R = R_1 + R_2 + \ldots$ for resistors connected in series $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$ for resistors connected in parallel	• Quantitative problems involving simple parallel and series circuits *are required* • The concept of the conservation of charge and energy of a closed circuit *is required*
simple circuits	• measure *I*, *V* and *R* in simple circuits • assign the electrical potential of any earthed points as zero • compare the e.m.f. of a source and the terminal voltage across the source experimentally and relate the difference to the internal resistance of the source • explain the effects of resistance of ammeters and voltmeters on measurements • solve problems involving simple circuits	• The structure of ammeter and voltmeter, and operation principles *are not required* • Loading effect of ammeter and voltmeter on measurement *is required* • Concept of potential divider *is required* • Problems on converting a moving coil meter by using a shunt or a multiplier *are not required* • Concept of internal resistance of a power supply (e.g. battery) *is required* ☺ Digital multimeter could be used to measure current (A), voltage (V) and resistance (Ω)

☺ Learning and teaching strategies for reference only.

Topics	Content	Notes for Teachers
electrical power	• examine the heating effect when a current passes through a conductor • apply $P = VI$ to solve problems	• Same treatment as in HKCEE • Calculating the power rating and maximum possible current of an appliance *is required* • Applying $V=IR$ and $P=VI$ to solve problems *is required*
domestic electricity	• determine the power rating of electrical appliances • use kilowatt-hour (kWh) as a unit of electrical energy • calculate the costs of running various electrical appliances • understand household wiring and discuss safety aspects of domestic electricity • determine the operating current for electrical appliances • discuss the choice of power cables and fuses for electrical appliances based on the power rating	• Same treatment as in HKCEE • Understanding of household wiring and discussing safety aspects (e.g. live / neutral / earth wires) *are required* • Function of earth wire to prevent electric shock *is required* • The use of fuse and circuit breaker as a safety device is required, but detailed structure of them *is not required* • Ring circuit in domestic electricity *is required*
(c) Electromagnetism		
magnetic force and magnetic field	• realise the attraction and repulsion between magnetic poles • examine the magnetic field in the region around a magnet • describe the behaviour of a compass in a magnetic field • represent magnetic field using field lines	☺ Plotting compass, hall probe, current balance and search coil could be used to examine magnetic field
magnetic effect of electric current	• realise the existence of a magnetic field due to moving charges or electric currents • examine the magnetic field patterns associated with currents through a long straight wire, a circular coil and a long solenoid • apply $B = \frac{\mu_o I}{2\pi r}$ and $B = \frac{\mu_o NI}{l}$ to represent the magnetic fields around a long straight wire, and inside a long solenoid carrying current, and solve related problems • examine the factors affecting the strength of an electromagnet	• Use Tesla (T) as a unit of magnetic flux density B • Numerical problems involving magnetic fields around a straight wire, and inside a long solenoid carrying current *are required* • Derivation of the equations $B = \frac{\mu_o I}{2\pi r}$ and $B = \frac{\mu_o NI}{l}$ by ampere's law *is not required*

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Topics	Content	Notes for Teachers
force due to magnetic field	• examine the existence of a force on a current-carrying conductor in a magnetic field and determine the relative directions of force, field and current • determine the factors affecting the force on a straight current-carrying wire in a magnetic field and represent the force by $F = BIl \sin \theta$ • determine the turning effect on a current-carrying coil in a magnetic field • describe the structure of a simple d.c. motor and how it works • solve problems involving current-carrying conductors in a magnetic field • represent the force on a moving charge in a magnetic field by $F = BQv \sin \theta$ and solve problems	• Quantitative treatment of the force between currents in long straight parallel conductors *is required* • Turning moment (torque) of a current carrying coil in a magnetic field *is required* • Principles of design / structure and operation of a moving-coil galvanometer *are not required* • Relative directions of force, field and current *is required* • Moment of a force is introduced in " Force and Motion" • Calculating resultant force on a moving charged particle in a magnetic field *is required*
electromagnetic induction	• examine induced e.m.f. resulting from a moving conductor in a steady magnetic field or a stationary conductor in a changing magnetic field • apply Lenz's law to determine the direction of induced e.m.f./current • define magnetic flux $\Phi = BA \cos \theta$ and weber (Wb) as a unit of magnetic flux • interpret magnetic field B as magnetic flux density • State Faraday's Law as $\varepsilon = -\frac{\Delta \Phi}{\Delta t}$ and apply it to calculate the average induced e.m.f. • examine magnetic fields using a search coil • describe the structures of simple d.c. and a.c. generators and how they work • discuss the occurrence and practical uses of eddy currents	• Numerical problems on the application of Faraday's law are required ☺ Using CRO as a meter / detector in practical work is encouraged. The detailed structure of CRO *is not required* ☺ Using induction cooking as an example of practical uses of eddy currents is encouraged
alternating currents (a.c.)	• distinguish between direct currents (d.c.) and alternating currents (a.c.) • define r.m.s. of an alternating current as the steady d.c. which converts electric potential energy to other forms in a given pure resistance at the same rate as that of the a.c. • relate the r.m.s. and peak values of an a.c.	• Relate the r.m.s. and peak value of an a.c. for sinusoidal waves only Mathematics skills involved: Compulsory Part in Math • 13.1 understand the functions sine, cosine and tangent, and their graphs and properties, including maximum and minimum values and periodicity

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Topics	Content	Notes for Teachers
transformer	• describe the structure of a simple transformer and how it works • relate the voltage ratio to turn ratio by $\frac{V_p}{V_s} = \frac{N_p}{N_s}$ and apply it solve problems • examine methods for improving the efficiency of a transformer	• Same treatment as in HKCEE • Ohmic loss and eddy current loss *are required*
high voltage transmission of electrical energy	• discuss the advantages of transmission of electrical energy with a.c. at high voltages • describe various stages of stepping up and down of the voltage in a grid system for power transmission	• Same treatment as in HKCEE

Radioactivity and Nuclear Energy (16 hours)

Topics	Content	Notes for teachers
(a) Radiation and radioactivity		
X-rays	• realise X-rays as ionizing electromagnetic radiations of short wavelengths with high penetrating power • realise the emission of X-rays when fast electrons hit a heavy metal target • discuss the uses of X-rays	• X-ray spectrum and the detailed production mechanism of X- rays *are not required*
α, β and γ radiations	• describe the origin and nature of α, β and γ radiations • compare α, β and γ radiations in terms of their penetrating power, ranges, ionizing power, behaviour in electric field and magnetic field, and cloud chamber tracks	• Qualitative treatment only for the penetration power of the three type of radiations • Quantitative treatment of attenuation of radiation *is not required*.
radioactive decay	• realise the occurrence of radioactive decay in unstable nuclides • examine the random nature of radioactive decay • state the proportional relationship between the activity of a sample and the number of undecayed nuclei • define half-life as the period of time over which the number of radioactive nuclei decreases by a factor of one-half • determine the half-life of a radioisotope from its decay graph or from numerical data • realise the existence of background radiation • solve problems involving radioactive decay • represent the number of undecayed nuclei by the exponential law of decay $N = N_o e^{-kt}$ • apply the exponential law of decay $N = N_o e^{-kt}$ to solve problems • relate the decay constant and the half-life	• Using linear scale graph to plot decay curve *is expected*, but using log graph to plot decay curve *is not required* • Mixture of radioactive sources for simple cases only • Conservation of charge and mass number in decay series is required • Interpretation of decay constant k as the constant chance of an atom decaying per unit time • Carbon dating *is required* • Derivation of exponential law of decay *is not required* • The conversion of measured radioactivity in unit of cps to the absolute radioactivity of the sample in Bq *is not required*. • The effect of background radiation to the measurement of radioactivity *is required.* • Factors, such as detector efficiency, counting geometry, self-absorption of the radiation in the sample, which affect the absolute measurement of radioactivity *are not required* ☺ Note the difference between measured radioactivity and the absolute radioactivity of a radioactive sample. The Becquerel (Bq) is an absolute radioactivity while count per second (cps) is a measured radioactivity. (For teacher's reference) ☺ The Becquerel (Bq) is the SI-derived unit of radioactivity. One Bq is defined as the activity of a quantity of radioactive material in which one nucleus decays per second. The Bq unit is therefore equivalent to s^{-1} (For teacher's reference)

☺ Learning and teaching strategies for reference only.

Topics	Content	Notes for teachers
		Mathematics skills involved: Compulsory Part in Math - 3. Exponential and logarithmic functions • Module 1 (Calculus and Statistics) – 2. Exponential and Logarithmic functions • Module 2 (Algebra and Calculus) – 5. Introduction to the number *e*
detection of radiation	• detect radiation with a photographic film and GM counter • detect radiation in terms of count rate using a GM counter	• Suitability of photographic film and GM counter for detection of α, β and γ emissions *is required* • Familiarity with cloud chamber tracks (in photography) *is required* • The structure and operation principle of an ionization chamber and a cloud chamber *are not required*
radiation safety	• represent radiation equivalent dose using the unit sievert (Sv) • discuss potential hazards of ionizing radiation and the ways to minimise the radiation dose absorbed • suggest safety precautions in handling radioactive sources	• Sources of background radiation and typical radiation doses *is required* ☺ Note the exposure time and radiation exposure level for estimating the radiation dosage (For teacher's reference)
(b) Atomic model		
atomic structure	• describe the structure of an atom • define atomic number as the number of protons in the nucleus and mass number as the sum of the number of protons and neutrons in the nucleus of an atom • use symbolic notations to represent nuclides	• Same treatment as HKCEE
isotopes and radioactive transmutation	• define isotope • realise the existence of radioactive isotopes in some elements • discuss uses of radioactive isotopes • represent radioactive transmutations in α, β and γ decays using equations	• Same treatment as HKCEE
(c) Nuclear energy		
nuclear fission and fusion	• realise the release of energy in nuclear fission and fusion • realise nuclear chain reaction • realise nuclear fusion as the source of solar energy	• Operation principle of nuclear power station, structure of nuclear reactor, control rods / moderators *are not required*
mass-energy relationship	• state mass-energy relationship $\Delta E = \Delta m\, c^2$ • use atomic mass unit as a unit of energy • determine the energy release in nuclear reactions • apply $\Delta E = \Delta m\, c^2$ to solve problems	• If conversion between units (u, MeV and J) is required, the following will be given: 1 u = 931 MeV • Mole, molar mass and Avogadro's number *are required*

☺ Learning and teaching strategies for reference only.

SS Physics Curriculum- Elective Part (for students taking 2016 and after 2016 HKDSE)

Astronomy and Space Science (25 hours)

Topics	Content	Notes for teachers
(a) The universe as seen in different scales		
structure of the universe	• use the "Powers of Ten" approach to describe the basic features and hierarchy of celestial bodies such as satellite, planet, star, star cluster, nebula, galaxy and cluster of galaxies, as seen in different spatial scales • define the basic terminologies such as light year and astronomical unit for describing the spatial scale	• A brief introduction to the relative order of magnitude of the celestial bodies only, exact values *are not required* • The names of the eight planets of the solar system *are not required*
(b) Astronomy through history		
models of planetary motion	• compare the heliocentric model with the geocentric model in explaining the motion of planets on the celestial sphere • describe Galileo's astronomical discoveries and discuss their implications • describe planetary motion using Kepler's laws	• A brief historic review of geocentric model and heliocentric model serves to stimulate students to think critically about how scientific hypotheses were built on the basis of observation • Realize the retrograde motion of planets • Note that the planets Mercury and Venus always appear close to the Sun • Be familiar with the basic terminologies of an ellipse (focus and semi-major axis) • Variation of speed in elliptical orbit is expected (Kepler's Second Law) • Angular momentum *is not required*
(c) Orbital motions under gravity		
Newton's law of gravitation	• apply Newton's law of gravitation $F = \frac{GMm}{r^2}$ to explain the motion of celestial bodies in circular orbits • derive Kepler's third law $T^2 \propto r^3$ for circular orbits from Newton's law of gravitation • state Kepler's third law for elliptical orbits $T^2 = \frac{4\pi^2 a^3}{GM}$ • apply Kepler's third law to solve problems involving circular and elliptical orbits	• "Uniform circular motion" and "Gravitation" are introduced in the Compulsory Part - "Force and Motion" • Application of the Kepler's third law to solve problems involving elliptical orbits by using semi-major axis (a) instead of radius (r) *is required* • Solving problems involving the motion of planets, moons and satellites *is required* • Direct application of T^2 (in Earth years) = a^3 (in AU) to orbital motions around the Sun *is not required*
weightlessness	• explain apparent weightlessness in an orbiting spacecraft as a result of acceleration due to gravity being independent of mass	

Topics	Content	Notes for teachers
conservation of energy	• interpret the meaning of gravitational potential energy and its expression $U = -\frac{GMm}{r}$ • apply conservation of mechanical energy to solve problems involving the motion of celestial bodies or spacecraft • determine the escape velocity on a celestial body	• Discussion of the motion of a satellite with an energy loss *is not required*
(d) Stars and the universe		
stellar luminosity and classification	• determine the distance of a celestial body using the method of parallax • use parsec (pc) as a unit of distance • realise magnitude as a measure of brightness of celestial bodies • distinguish between apparent magnitude and absolute magnitude • describe the effect of surface temperature on the colour and luminosity of a star using blackbody radiation curves • realise the existence of spectral lines in the spectra of stars • state major spectral classes: O B A F G K M and relate them to the surface temperature of stars • state Stefan's law and apply it to derive the luminosity $L = 4\pi R^2 \sigma T^4$ for a spherical blackbody • represent information of classification for stars on the Hertzsprung-Russell (H-R) diagram according to their luminosities and surface temperatures • use H-R diagram and Stefan's law to estimate the relative sizes of stars	• Use of $d = 1/p$ (where p is in arc-seconds, d is in parsecs) and quantitative analysis of photographic images to determine the distance of celestial body is required. As a unit of distance, parsecs can be expressed in AU or light years. • Calculation of apparent magnitude and absolute magnitude *is not required but qualitative treatment is expected* • The surface temperature of stars in relation to their spectral classes *is not required* • Stellar evolution *is not required* ☺ Note that Stefan's law gives the radiant power output per unit surface area of a blackbody while luminosity gives the absolute (total) radiant power output of an object ☺ Note that absolute magnitude or luminosity (Sun = 1) of stars is taken as the y-axis while surface temperature of stars is taken as the x-axis in the H-R diagram Mathematics skills involved Module 2 (Algebra and Calculus) in Math - (4) More about trigonometric Functions • 4.1 understand the concept of radian measure • 4.2 find arc lengths and areas of sectors through radian measure
Doppler effect	• realise the Doppler effect and apply $\frac{\Delta\lambda}{\lambda_o} \approx \frac{v_r}{c}$ to determine the radial velocity of celestial bodies • use the radial velocity curve to determine the orbital radius, speed, and period of a small celestial body in circular orbital motion around a massive body as seen along the orbital plane • relate the rotation curve of stars around galaxies to the existence of dark matter • relate the red shift to the expansion of the universe	• Simple application of Doppler effect and radial velocity curve is expected • Simple qualitative understanding of the problems related to dark matter and expansion of the universe *is expected*

Atomic World (25 hours)

Topics	Content	Notes for teachers
(a) Rutherford's atomic model		
the structure of atom	• describe Rutherford's construction of an atomic model consisting of a nucleus and electrons • state the limitations of Rutherford's atomic model in accounting for the motion of electrons around the nucleus and line spectra • realise the importance of scattering experiments in the discovery of the structure of atoms and the impact on the searching for new particles	• Note that scattering experiments are commonly used in modern physics researches for finding the structure of atoms and searching for new particles • The setups of different scattering experiments and the names of new particles found by the scattering experiments *are not required*
(b) Photoelectric effect		
evidence for light quanta	• describe photoelectric effect experiment and its results • state the limitations of the wave model of light in explaining the photoelectric effect	• The use of gold-leaf electroscope in photoelectric effect experiment *is not required* • The use of photocell in photoelectric effect experiment *is implied* • Applications of photocell *are not required*
Einstein's interpretation of photoelectric effect and photoelectric equation	• state photon energy $E = hf$ • describe how the intensity of the incident light of a given frequency is related to the number of photons • explain photoelectric effect using Einstein's photoelectric equation $hf - \phi = \frac{1}{2} m_e v_{\max}{}^2$ • realise the photoelectric effect as the evidence of particle nature of light • apply $E = hf$ and Einstein's photoelectric equation to solve problems	• Stopping potential of photoelectrons in photoelectric effect experiments *is implied* • Expressing work function in terms of threshold frequency ($\phi = hf_0$) *is required* • Millikan's photoelectric experiment *is not required*
(c) Bohr's atomic model of hydrogen		
line spectra	• describe the special features of line spectra of hydrogen atoms and other monatomic gases • explain spectral lines in terms of difference in energies • realise that the energy of a hydrogen atom can only take on certain values • realise line spectra as evidence of energy levels of atoms	• The names of spectral series (e.g. Lyman, Balmer and Paschen) *are not required*

Topics	Content	Notes for teachers
Bohr's model of hydrogen atom	• state the postulates that define Bohr's model of hydrogen atom • distinguish between the "quantum" and "classical" aspects in the postulates of Bohr's atomic model of hydrogen • realise the postulate $m_e vr = \frac{nh}{2\pi}$ as the quantization of angular momentum of an electron around a hydrogen nucleus where *n*=1,2,3… is the quantum number labelling the n^{th} Bohr orbit of the electron • realise the equation for the energy of an electron in a hydrogen atom as $E_{tot}\ (= -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_o^2}\right\}) = -\frac{13.6}{n^2}$ eV • use electron-volt (eV) as a unit of energy • distinguish ionization and excitation energies • apply $E_{tot} = -\frac{13.6\text{ eV}}{n^2}$ to solve problems	• Basic knowledge of angular momentum = *mvr is expected* • The derivation of the postulate $m_e vr = \frac{nh}{2\pi}$ is not required ☺ Noted that electric potential energy ($E_p = \frac{-e^2}{4\pi\varepsilon_0 r}$) and kinetic energy ($E_k = \frac{1}{2}m_e v^2$) can be used to explain the total energy of an electron in a hydrogen atom
the interpretation of line spectra	• derive, by using Bohr's equation of electron energy and *E*=*hf*, the expression $\frac{1}{\lambda_{a\to b}} = \frac{13.6\text{ eV}}{hc}\left\{\frac{1}{b^2} - \frac{1}{a^2}\right\}$ for the wavelength of photon emitted or absorbed when an electron undergoes a transition from one energy level to another • interpret line spectra by the use of Bohr's equation of electron energy • apply *E*=*hf* and $\frac{1}{\lambda_{a\to b}} = \frac{13.6\text{ eV}}{hc}\left\{\frac{1}{b^2} - \frac{1}{a^2}\right\}$ to solve problems	• Note that the expression is only for photon emission where "*a*" is the higher level and "*b*" is the lower level" • For the case of photon absorption ("*a*" is the lower level and "*b*" is the higher level), the expression is given by $\frac{1}{\lambda_{a\to b}} = \frac{13.6\text{ eV}}{hc}\left\{\frac{1}{a^2} - \frac{1}{b^2}\right\}$ • The existence of dark lines (Fraunhöfer lines) in Sun's spectrum is used to illustrate absorption spectrum • Emission line spectrum in monatomic gas discharge tube is used to illustrate emission spectrum
(d) Particles or Waves		
	• realise the wave-particle duality of electrons and light • describe evidences of electrons and light exhibiting both wave and particle properties • relate the wave and particle properties of electrons using the de Broglie formula $\lambda = \frac{h}{p}$	☺ Note that the de Broglie formula $\lambda = \frac{h}{p}$ can be used to explain the quantization of angular momentum $m_e vr = \frac{nh}{2\pi}$

☺ Learning and teaching strategies for reference only.

Topics	Content	Notes for teachers
	• apply $\lambda = \frac{h}{p}$ to solve problems	
(e) Probing into nano scale		
physical properties of materials in nano scale	• understand that nano means 10^{-9} • realise that materials in nano scale can exist in various forms, such as nano wires, nano tubes and nano particles • realise that materials often exhibit different physical properties when their sizes are reduced to nano scale	• Note that different arrangements of atoms lead to different physical properties (can be illustrated using the different forms of carbon) • Limited to the following physical properties: optical (e.g. colour, transparency), mechanical (e.g. strength, hardness) and electrical (e.g. conductivity) properties
seeing at nano scale	• describe the limitations of optical microscope in seeing substances of small scale • describe how a transmission electron microscope (TEM) works • draw the analogy between the use of electric and magnetic fields in TEMs and lenses in optical microscopes • estimate the anode voltage needed in a TEM to accelerate electrons achieving wavelengths of the order of atomic size • explain the advantage of high resolution of TEM using Rayleigh criterion for minimum resolvable detail, $\theta \approx \frac{1.22\lambda}{d}$ • describe how a scanning tunnelling microscope (STM) works in seeing nano particles (principles of the tunnelling effect are not required)	• Spherical and chromatic aberrations of optical microscope *are not required* • Detailed mechanism of focusing by electric and magnetic fields in TEM *is not required* • Derivation of $\theta \approx \frac{1.22\lambda}{d}$ *is not required*
recent development in nanotechnology	• describe recent developments and applications of nanotechnology in various areas related to daily life • discuss potential hazards, issues of risks and safety concerns for our lives and society in using nanotechnology	• Current developments and daily life applications of nanotechnology including: (1) Materials (stain-resistant fibres, anti-bacterial / detoxicating / de-odorising nano paint, strong / flexible / light / conductive materials); (2) Information technology (better data storage and computation); and (3) Health care & Environment (chemical and biological sensors, drugs and delivery devices, clean energy, clean air and water) *are expected* • Note that nanotechnology is still developing • Note that the long term effect of nano materials to safety, health, and environment is still under investigation

Topics	Content	Notes for teachers
		☺ Information search could be arranged on the recent development in nanotechnology ☺ Debates could be arranged on discussing potential hazards, issues of risks and safety concerns in using nanotechnology

Energy and Use of Energy (25 hours)

Topics	Content	Notes for teachers
(a) Electricity at home		
energy consuming appliances at home	• state electricity as the main source for domestic energy • describe the energy conversion involved in electrical appliances • define end-use energy efficiency in terms of the ratio of the amount of useful energy output to energy input	• Identification of energy input and useful energy output in different appliances *is required* • Note that the concept of end-use energy efficiency and its application to solve problems *are required*
lighting	• state the different types of lighting used at home • describe how incandescent lamps, gas discharge lamps and light emitting diodes (LED) work and interpret light emission in terms of energy change in atomic level • discuss cost effectiveness of incandescent lamps, gas discharge lamps and light emitting diodes • realise that the eye response depends on wavelengths • define luminous flux as the energy of light emitted per unit time by a light source • use lumen as a unit of luminous flux • define illuminance as luminous flux falling on unit area of a surface • use lux as a unit of illuminance • use inverse square law and Lambert's cosine law to solve problems involving illuminance • define efficacy of electric lights as a ratio of luminous flux (lm) to electrical power input (W) and solve related problems	• Note that the response of our light sensitive cells is frequency dependent • Quantitative treatment of efficacy of electric lights *is required*
cooking without fire	• describe how electric hotplates, induction cookers and microwave ovens work in heat generation • use the power rating of cookers to determine running cost • solve problems involving end-use energy efficiency of cookers • discuss the advantages and disadvantages of electric hotplates, induction cookers and microwave ovens	• Same treatment as HKCEE

Topics	**Content**	**Notes for teachers**
moving heat around	• describe how air-conditioner as a heat pump transfers heat against its natural direction of flow • interpret cooling capacity as the rate at which a cooling appliance is capable of removing heat from a room and use kilowatt (kW) as a unit for cooling capacity to solve related problems • define coefficient of performance COP as ratio of cooling capacity to electrical power input and solve related problems • discuss possible ways of using heat generated by central air-conditioning systems	• Simple qualitative treatment of heat transfer during compression and expansion *is implied* • 1st law of thermodynamics ($\Delta U=Q+W$) *is not required* • Quantitative treatment of COP *is required*
Energy Efficiency Labelling Scheme	• discuss the uses of the Hong Kong Energy Efficiency Labelling Scheme (EELS) for energy-saving • solve problems involving EELS • suggest examples of energy-saving devices	• Interpretation of Energy Efficiency Label of electrical appliances *is required* • EELS classifies the energy performance of appliances into five grades from 1 to 5. Grade 1 is the most efficient and 5 is the least efficient in that category
(b) Energy efficiency in building and transportation		
building materials used to improve the energy efficiency	• Interpret $\frac{Q}{t}=\frac{\kappa}{d}A(T_{hot}-T_{cold})$ as the rate of energy transfer by conduction and discuss the heat loss in conduction • define thermal transmittance U-value of building materials as $u=\frac{\kappa}{d}$ and solve related problems • define the Overall Thermal Transfer Value (OTTV) as the average rate of heat gain per unit area into a building through the building envelope and solve related problems • discuss factors affecting the OTTV • discuss the use of solar control window film in a building • discuss the factors affecting the energy efficiency of buildings	• Note that OTTV can be expressed by $\text{OTTV}=\frac{P_T}{A_T}=\frac{P_c+P_s}{A_T}$ where P_c refers to average rate of heat gain due to conduction and P_s denotes average rate of heat gain due to solar radiation • The term building envelope refers to the outermost layer of a building. It includes the roof, the walls and windows of all sides • Qualitative treatment of solar control window film which selectively permits the transmission of EMW *is required* ☺ Teachers may refer to the "Teaching Kit for the Appreciation of Architecture in Secondary School Curriculum" for the detailed discussion of OTTV and calculation of OTTV. (http://minisite.proj.hkedcity.net/hkiakit/cht/Science/index.html)
electric vehicles	• state the main components of the power system of electric vehicles • discuss the use of electric vehicles • state the main components of the power system of hybrid vehicles and compare their end-use energy efficiency to fossil-fuel vehicles	• Qualitative treatment of the function of the main components of EVs and hybrid vehicles *is implied* • Detailed internal function of the battery of EVs *is not required* • Note that the use of EVs is to reduce pollutants in urban area • Pros and cons of fossil-fuel vehicles and hybrid vehicles *is implied*

☺ Learning and teaching strategies for reference only.

Topics	Content	Notes for teachers
	• discuss the advantages of public transportation systems and give examples	
(c) Renewable and non-renewable energy sources		
renewable and non-renewable energy sources	• describe the characteristics of renewable and non-renewable energy sources and give examples • define solar constant as the total electromagnetic radiation energy radiated at normal incidence by the Sun per unit time per unit area at the mean distance between the Earth and the Sun measured outside the Earth's atmosphere • solve problems involving the solar constant • derive maximum power by wind turbine as $P = \frac{1}{2}\eta\rho A v^3$, where η is the efficiency and solve problems • describe the energy conversion process for hydroelectric power and solve problems • define binding energy per nucleon in unit of eV and solve problems • relate the binding energy curve to nuclear fission and fusion • describe the principle of the fission reactor and state the roles of moderator, coolant and control rods • describe how a solar cell works	• Note that the power output of a wind turbine depends on the efficiency of converting the kinetic energy of air into electrical energy and is typically only 30% – 40% of the maximum power ☺ Simple concept of a solar cell in terms of the electric field across PN junction which provides the voltage needed to drive the current through an external load. By absorbing photon energy, bounded electron is able to escape from its normal position to become part of the current in an electrical circuit (For teachers' reference)
environmental impact of energy consumption	• discuss the impact of extraction, conversion, distribution and use of energy on the environment and society • discuss effect of greenhouse gases on global warming • analyse the consumption data for different fuel types in Hong Kong and their specific purposes	• Hong Kong Energy End-use Data, the consumption data of the different energy fuel types and the specific purposes for which these fuels are consumed can be found in EMSD website (http://www.emsd.gov.hk/emsd/eng/pee/edata.shtml)

☺ Learning and teaching strategies for reference only.

Medical Physics (25 hours)

Topics	Content	Notes for teachers
(a) Making sense of the eye and the ear		
physics of vision	• describe the function of light sensitive cells (rods and cones) of retina in vision • interpret spectral response of light sensitive cells using receptor absorption curves • apply resolving power $\theta \approx \frac{1.22\lambda}{d}$ to solve problems • describe the process of accommodation of the eye	• Relate accommodation process of the eye to physics principles by referring to the basic structure of eye (same treatment as HKCEE) • Interpret response curve of the light sensitive cells (rods and cones) to visible light • Note that the response of the light sensitive cells is dependent on the brightness of environment • Relate resolving power to the ability of an eye to distinguish small details of an object • Derivation of $\theta \approx \frac{1.22\lambda}{d}$ *is not required* • Relate angular resolution to the spatial resolution by multiplication of the angle (in radians) with the distance to the object
defects of vision and their corrections	• define power of a lens as the reciprocal of the focal length of a lens • use dioptre as a unit of power of a lens • state the near point and far point of the eye • describe the defects of vision including short sight (myopia), long sight (hypermetropia) and old sight (presbyopia) and their corrections	• The optical power (dioptre) is adjusted by changing the form (curvature) of the elastic lens using the ciliary muscle • Note that optical powers are approximately additive for thin lenses placed close together • Note that distance of the near point of accommodation from the eyes increases with age • Presbyopia occurs when the near point of the eye is beyond the reading distance
physics of hearing	• describe the pressure amplification in the middle ear • realise the response of the inner ear to incoming sound waves • realise hearing perception of relative sound intensity levels and the need for a logarithmic scale to represent the levels • apply sound intensity level $L = 10\, log_{10}\left(\frac{I}{I_o}\right)$ dB to solve problems • interpret the curves of equal loudness • discuss the effects of noise on health of hearing	• Note that pressure amplification is a combination of the lever action of the 3 ear bones and the area ratio of the ear drum and the oval window. Detail of the lever action of the 3 ear bones *is not required* • Note that cochlea acts as a frequency analyser - regions nearer its base resonate with higher-frequency signals; regions closer to its apex resonate with lower-frequency ones. Detail of inner ear structure *is not required*. • Similar treatment of sound intensity level as HKAL, but pressure level *is not required* • Relate equal loudness curves and loudness level (phons) to sound intensity level (dB) of a pure note at 1 kHz

Topics	Content	Notes for teachers
(b) Medical imaging using non-ionizing radiation		
properties of ultrasound	• describe how a piezoelectric transducer works in generating and detecting an ultrasound pulse • define acoustic impedance $Z = \rho c$ and compare the acoustic impedances of various body tissues • apply intensity reflection coefficient $\alpha = \frac{I_r}{I_o} = \frac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2}$ to solve problems • realise the dependence of attenuation of ultrasound on the nature of the medium and the frequency	• Relate piezoelectric properties of a crystal to the generation and detection of ultrasound • Apply intensity reflection coefficient α to estimate the reflected and transmitted intensity of a ultrasound pulse across a boundary • Note that penetration depth of a ultrasound beam is frequency dependent • Compensation of attenuation loss of a return pulse *is not required* Mathematics skills involved Compulsory Part in Math - 3. Exponential and logarithmic functions • Module 1 (Calculus and Statistics) - 2. Exponential and Logarithmic functions • Module 2 (Algebra and Calculus) - 5. Introduction to the number *e*
ultrasound scans	• realise A-scan and B-scan as range-measuring systems • describe how A-scan works • interpret the pulse display of A-scan • identify suitable frequency ranges of ultrasound for scanning based on penetration depth, resolution and body structures • describe how B-scan works • estimate the size of a body tissue in a B-scan image • discuss the advantages and limitations of ultrasound scans in diagnosis	• Prior knowledge of pulse-echo measurements in sound waves *is assumed* • Prior knowledge of wave nature of sound (reflection, refraction, diffraction and interference) in " Wave Motion" *is assumed* • Distinguish between the working principles of A-scan and B-scan • Understanding of the factors affecting the penetration depth and resolution, and hence the choice of frequencies for medical scanning
fibre optic endoscopy	• describe the characteristics of an optical fibre • describe how a fibre optic endoscope works • describe how coherent bundle fibres form image • solve problems involving optical fibre • discuss the advantages and limitations of using endoscope in diagnosis	• Prior knowledge of refraction of light (Snell's Law) and total internal reflection *is assumed* • Basic components of a fibre optic endoscope such as lighting, lens system (objective & eyepiece) and imaging system *are required* • Note that fibre optic bundles are used to convey light from source to distal tip, and carry image back to the eye / video monitor
(c) Medical imaging using ionizing radiation		
X-ray radiographic imaging	• apply $I = I_o e^{-\mu x}$ to determine the transmitted intensity of a X-ray beam after travelling through a certain thickness in a medium	• Prior knowledge of exponential law of decay in 'Radioactivity and Nuclear Energy' *is assumed*

Topics	Content	Notes for teachers
	• relate the linear attenuation coefficient (μ) to half-value thickness • realise a radiographic image as a map of attenuation of X-ray beam after passing body tissues • explain the use of artificial contrast media such as barium meal in radiographic imaging • discuss the advantages and disadvantages of radiographic imaging in diagnosis	• Derivation of half-value thickness $\frac{ln\ 2}{\mu}$ and its application to solve problems *is required* • Note that attenuation coefficient μ depends on tissue density • Relate a radiographic image to the X-ray intensity transmitted through the body • Note that a X-ray radiographic image is a 2D projection of the X-ray attenuation of a 3D object
CT scan	• describe how a computed tomography (CT) scanner works • realise a CT image as a map of attenuation coefficients of body tissues • realise the image reconstruction process of CT scanning • compare CT images with X-ray radiographic images	• Detailed structure of CT machine *is not required* • Note that the CT image is reconstructed by back-projection of attenuation profiles • CT number *is not required* • The differences in the use of CT images and X-ray radiographic images *is required*
radionuclides for medical uses	• identify the characteristics of radionuclides such as technetium-99m used for diagnosis • define biological half-life as the time taken for half the materials to be removed from the body by biological processes and apply it to solve related problems • describe the use of radioisotopes as tracers for diagnosis • realise a radionuclide image obtained by a gamma camera as a map of radioisotopes distribution in a body • compare radionuclide planar images with X-ray radiographic images • compare effective dose in diagnostic medical procedures involving ionizing radiation • discuss the health risk and safety precautions for ionizing radiation	• The relationship between effective half-life, biological half-life and physical half-life is required • Calculation of effective half-life of a radionuclide from its biological and physical half-life *is required* • Application of effective half-life to solve problems *is required* • Detailed structure of gamma camera *is not required* • The differences in the use of radionuclide images and X-ray radiographic images *are required* • Note that ionizing radiation used in medical imaging may lead to health risk