Alberta Physics Standards Correlation

Physics 20 and Physics 30 Specific Learner Expectations: Knowledge

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
Physics 20			
Unit 1: Kinematics and Dynamics			
1. Change in the position and velocity of objects and systems can be described graphically and mathematically.			
· the motion of objects and systems can be described in terms of displacement, time, velocity and acceleration, by extending from Science 10, Unit 4, the principles of one-dimensional motion, and by:	Chapter 2	Chapter 2	Chapter 2
· defining, operationally, and comparing and contrasting scalar and vector quantities	3.1 - 3.2	3.1 - 3.2	3.1 - 3.2
· defining velocity as a change in position during a time interval	2.3 - 2.5	2.3 - 2.5	2.3 - 2.5
· defining acceleration as a change in velocity during a time interval	2.10 - 2.12	2.10 - 2.12	2.8 - 2.10
· comparing motion with constant velocity and variable velocity, and motion with constant acceleration and variable acceleration, average and instantaneous velocity	Chapter 2	Chapter 2	Chapter 2
· explaining uniform motion and uniformly accelerated motion, using position–time, velocity–time and acceleration–time graphs	2.6 - 2.7, 2.9	2.6 - 2.7, 2.9	2.6 - 2.7
· applying the concepts of slope and area under a line or curve to determine velocity, displacement and acceleration from position–time and velocity–time graphs	2.6 - 2.7, 2.9, 2.12	2.6 - 2.7, 2.9, 2.12	2.6 - 2.7, 2.10
· explaining, quantitatively, two-dimensional motion, in horizontal or vertical planes, using vector components addition	3.6, Chapter 4	3.6, Chapter 4	3.6, Chapter 4
· explaining the uniform motion of objects, using algebraic and graphical methods, from verbal or written descriptions and mathematical data	Chapters 2-4	Chapters 2-4	Chapters 2-4
· explaining, quantitatively, the motion of one object relative to another object, using displacement and velocity vectors	4.22 - 4.25	4.21 - 4.23	4.14 - 4.15
· using the delta notation correctly when describing change in quantities	2.2	2.2	2.2
· using unit analysis to check the results of mathematical solutions.	1.10	1.10	
2. The concepts of dynamics explicitly relate forces to change in velocity.			

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
· changes in velocity are the result of a non-zero net force, by recalling from Science 7, Unit 3, the notions of force, inertia and friction, and by:	Chapter 5	Chapter 5	Chapter 5
· comparing and contrasting among mass, volume and weight	5.3 - 5.4	5.3 - 5.4	5.3 - 5.4
· explaining how a force effects a change in motion	Chapter 5	Chapter 5	Chapter 5
· applying Newton's first law of motion to explain an object's state of rest or uniform motion	5.2	5.2	5.2
· applying Newton's second law of motion, and using it to relate force, mass and acceleration	5.5	5.5	5.5
· relating Newton's third law of motion to interaction between two objects, recognizing that the two forces, equal in magnitude and opposite in direction, act on different bodies	5.10, 5.13	5.10, 5.13	5.10, 5.13
· determining, quantitatively, the net or resultant force acting on an object, using vector components addition graphically and mathematically	5.14, Chapters 5 & 6	5.14, Chapters 5 & 6	5.14, Chapter 5
· applying Newton's laws of motion to solve, algebraically, linear motion problems in horizontal, vertical and inclined planes, near the surface of Earth (whenever friction is included, only the resistive effect of the force of friction is considered)	Chapters 5 & 6	Chapters 5 & 6	Chapter 5
· solving projectile motion problems near the surface of Earth, ignoring air resistance.	Chapter 4	Chapter 4	Chapter 4
3. Work is a transfer of energy.			
· mechanical energy exchanges involve changes in kinetic and/or potential energy, by extending the mechanical energy concepts studied in Science 10, Unit 4, and by:	Chapter 7	Chapter 7	Chapter 6
· defining work as a measure of the mechanical energy transferred	7.9, 7.17, 7.20	7.7, 7.14, 7.17	6.5, 6.11, 6.14
· defining, quantitatively, power as the rate of doing work	7.15	7.12	6.9
· analyzing, quantitatively, mechanical energy transformations, using the law of conservation of mechanical energy	7.22 - 7.25	7.19 - 7.22	6.16 - 6.19
Unit 2: Circular Motion and Gravitation			
1. Newton's laws of motion can be used to explain uniform circular motion.			

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
· uniform circular motion requires a non-zero net force of constant magnitude, by:	9.7	9.6	8.5
· describing uniform circular motion as a special case of two-dimensional motion	9.1	9.1	8.1
· describing forces in circular motion as gravitational, frictional, electrostatic	9.7, 30.12	9.6, 30.13	8.5, 28.13
· explaining, quantitatively, that the acceleration in circular motion is centripetal	9.4	9.4	8.3
· explaining, quantitatively, circular motion in terms of Newton's laws of motion	9.7	9.6	8.5
· solving, quantitatively, circular motion problems, using algebraic and/or graphical vector analysis	Chapter 9	Chapter 9	Chapter 8
· explaining, quantitatively, the relationships among speed, frequency, period and circular motion	9.2, 15.4	9.2, 15.3	8.2, 14.3
· analyzing, quantitatively, the motion of objects moving with constant speed in horizontal or vertical circles near the surface of Earth.	Chapter 9	Chapter 9	Chapter 8
2. Gravitational effects extend throughout the Universe.			
· gravity is a universal force of nature, by:	13.1	13.1	12.1
· explaining, qualitatively, how mechanical understanding of circular motion and Kepler's laws were used in the development of Newton's universal law of gravitation	Chapter 13	Chapter 13	Chapter 12
· explaining, qualitatively, the principles pertinent to the Cavendish experiment used to determine the gravitational constant, G	13.37 #A.10	13.30 #A.10	
· relating the universal gravitational constant to the local value of the acceleration due to gravity	13.2	13.2	12.2
· predicting, quantitatively, changes in weight that objects experience on different planets	5.4, 5.36: #4.1, #4.2, & #4.4	5.4, 5.35: #4.1, #4.2, & #4.4	5.4, 5.29: #4.1, #4.2, & #4.4
· defining "field" as a concept explaining action at a distance, and applying it to describing gravitational effects	13.10	24.1 (in context of electric fields)	23.1 (in context of electric fields)
· applying, quantitatively, Newton's second law, combined with the universal law of gravitation, to explain planetary and satellite motion, using the circular motion approximation	13.14 - 13.17	13.10 - 13.13	12.9 - 12.12
· predicting the mass of a planet from the orbital data of a satellite in uniform circular motion	13.14 - 13.15	13.10 - 13.11	12.9 - 12.10

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
· explaining, qualitatively, the shape of our solar system, and that of galaxies, in terms of Newton's laws of motion and Newton's law of gravitation.	Chapter 13	Chapter 13	Chapter 12
Unit 3: Mechanical Waves			
1. Many vibrations are simple harmonic.			
· simple harmonic motion is used to describe mechanical wave motion, by:	Chapters 15 & 16	Chapters 15 & 16	Chapters 14 & 15
· defining simple harmonic motion as motion toward a fixed point, with an acceleration, due to a restoring force, that is proportional to the displacement from the equilibrium position	15.1	15.1	14.1
· explaining, qualitatively, the relationships among displacement, acceleration, velocity and time, for simple harmonic motion, in terms of uniform circular motion	15.2, 15.10, 15.12, 15.16	15.2, 15.9, 15.11, 15.14	14.2, 14.7, 14.8
· explaining, quantitatively, the relationships among kinetic, potential and total mechanical energies of a mass executing simple harmonic motion	15.21	15.19	
· defining resonance, and giving examples of mechanical and/or acoustical resonance	15.35 - 15.36, 18.7, 18.10	15.28, 18.7, 18.10	14.14, 17.4
· describing wave motion in terms of the simple harmonic motion of particles.	16.3, 16.6, 17.1	16.3, 16.6, 17.1	15.3, 15.6, 16.1
2. Waves are a means of transmitting energy.			
· energy from simple harmonic motion can be transmitted as a wave through a medium, by:	Chapter 16	Chapter 16	Chapter 15
· describing medium particle vibrations as the source of mechanical waves	16.1, 17.1	16.1, 17.1	15.1, 16.1
· comparing and contrasting energy transmission by matter that moves and by waves that move	16.1, 17.1	16.1, 17.1	15.1, 16.1
· explaining the characteristics of waves in terms of the direction of vibration of the medium particles in relation to the direction of propagation of the disturbance	16.2	16.2	15.2
· defining and using the terms wavelength, amplitude, transverse and longitudinal, in describing waves	16.2 - 16.5	16.2 - 16.5	15.2 - 15.5
· explaining how a wave travels with a speed determined by the characteristics of the medium	16.7 - 16.8, 17.4	16.7 - 16.8, 17.4	15.7 - 15.8

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
· relating the frequency of a wave to the period of the source, and the speed of propagation to the frequency and wavelength	16.6 - 16.7	16.6 - 16.7	15.6 - 15.7
· predicting, quantitatively, and verifying, the effects of changing one, or a combination, of the variables in the relationship $v = f \lambda$	16.7	16.7	15.7
· explaining the behaviour of waves at the boundaries between mediums; e.g., reflection and refraction at “open” and “closed” ends	18.6, 18.9, 18.10, 37.7 - 37.8, 39.11	18.6, 18.9, 18.10, 36.7, 36.8, 38.7	17.3, 32.6
· predicting the resultant displacement when two waves interfere	18.15 - 18.16	18.14 - 18.15	17.7
· explaining the Doppler effect on a stationary observer with a moving source, and a moving observer with a stationary source.	17.14 - 17.20	17.12 - 17.17	16.7 - 16.8
Unit 4: Light			
1. Geometric optics is one model used to explain the nature and behaviour of light.			
· geometric optics can be used to explain observed phenomena of light, by:	Chapters 36, 37 & 38	Chapters 35, 36 & 37	Chapters 31, 32 & 33
· citing evidence for the linear propagation of light	35.2 - 35.4, 36.2	34.2, 35.2	30.2, 31.2
· explaining a method of measuring the speed of light	35.7	34.4	30.4
· calculating c, given experimental data of various methods employed to measure the speed of light			
· defining a ray as a straight line representing the rectilinear propagation of light	36.2	35.2	31.2
· explaining, using ray diagrams, the phenomena of dispersion, reflection and refraction at plane and uniformly curved surfaces	Chapters 36, 37 & 38	Chapters 35, 36 & 37	Chapters 31, 32 & 33
· stating and using Snell’s law in the form of $n_1 \sin \theta_1 = n_2 \sin \theta_2$	37.3 - 37.4	36.3 - 36.4	32.3 - 32.4
· deriving the curved mirror equation from empirical data	36.11, 36.21		
· solving reflection and refraction problems, using algebraic, trigonometric and graphical methods	Chapters 36, 37 & 38	Chapters 35, 36 & 37	Chapters 31, 32 & 33
· analyzing simple optical systems, consisting of no more than two lenses or one mirror and one lens, using algebraic and/or graphical methods.	38.13, 38.14 - 38.16, 38.21, 38.24 - 38.26	37.12, 37.13 - 37.15, 37.19, 37.22 - 37.24	33.9 - 33.11, 33.14

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
2. The wave model of light improves our understanding of the behaviour of light.			
· wave optics can explain light phenomena that geometric optics cannot, by recalling from Unit 3, the behaviour of waves during reflection, refraction and interference, and by:	Chapters 39 & 40	Chapters 38 & 39	Chapter 34
· comparing the explanations of reflection and refraction by the particle theory and by the wave theory of light	18.6, 18.9, 36.1 37.7 - 37.8	18.6, 18.9, 35.1, 36.7 - 36.8	17.3, 31.1, 32.6
· explaining, using the wave theory of light, the phenomena of reflection and refraction	18.6, 37.7 - 37.8	18.6, 36.7 - 36.8	17.3, 32.6
· explaining why geometric optics fail to adequately account for the phenomena of diffraction, interference and polarization	35.21, 39.0 - 39.1, 40.1	34.17, 38.0 - 38.1, 39.1	30.8, 34.0 - 34.1, 34.5
· explaining, qualitatively, diffraction and interference, using the wave model of light	39.0 - 39.1, 40.0 - 40.2	38.0 - 38.1, 39.0 - 39.2	34.0 - 34.1, 34.5 - 34.6
· explaining how the results of Young's double-slit experiment support the wave theory of light	39.2	38.2	34.2
· solving double-slit problems, using λ = xd/nl and diffraction grating problems, using λ = dsinθ/n	39.3, 40.16	38.3, 39.13	
· explaining, qualitatively, polarization in terms of the wave model of light	35.21 - 35.22	34.17 - 34.18	30.8
· demonstrating how Snell's law in the form sinθ1/sinθ2 = n2/n1=v1/v2= λ1/λ2 offers support for the wave model of light.	37.3, 37.7	36.3, 36.7	32.3
Physics 30			
Unit 1: Conservation Laws			
1. Conservation of energy in an isolated system is a fundamental physical concept.			
· mechanical energy interactions involve changes in kinetic and potential energy, by extending energy concepts from Science 10, Unit 4, and the mechanical energy concepts and problem-solving methods studied in Physics 20, Unit 1, and by:	Chapter 7	Chapter 7	Chapter 6
· describing energy and mass as scalar quantities	5.3, 7.7	5.3, 7.5	5.3, 6.3
· relating the conservation of mass and energy in a qualitative analysis of Einstein's concept of mass–energy equivalence	41.23	40.16	35.12
· defining mechanical energy as the sum of kinetic and potential energy	7.22	7.19	6.16

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
· solving conservation problems, using algebraic and/or graphical analysis	Chapters 7, 8, 21	Chapters 7, 8, 21	Chapters 6, 7, 20
· analyzing and solving, quantitatively, kinematics and dynamics problems, using mechanical energy conservation concepts by extending previous problem-solving methods.	Chapters 7, 8	Chapters 7, 8	Chapters 6, 7
2. Momentum is conserved when objects interact in an isolated system.			
· conservation laws provide a simple means to explain interactions among objects, by:	Chapter 8	Chapter 8	Chapter 7
· describing momentum as a vector quantity	8.1	8.1	7.1
· defining momentum as a quantity of motion equal to the product of the mass and the velocity of an object	8.1	8.1	7.1
· relating Newton's laws of motion, quantitatively, to explain the concepts of impulse and a change in momentum	8.2 - 8.4	8.2 - 8.3	7.2 - 7.3
· explaining, quantitatively, using vectors, that momentum appears to be conserved during one- and two-dimensional interactions in one plane among objects (the sine and cosine rules are not required)	8.7	8.6	7.5
· defining, comparing and contrasting elastic and inelastic collisions, using quantitative examples	8.11 - 8.21	8.10 - 8.19	7.8 - 7.13
· comparing scalar and vector conservation laws.	Chapters 7, 8	Chapters 7, 8	Chapters 6, 7
Unit 2: Electric Forces and Fields			
1. The laws governing electrical interactions are used to explain the behaviour of electric charges at rest.			
· the electrical model of matter is fundamental to the explanation of electrical interactions, by extending from Physics 20, Unit 1, and by:	Chapter 23	Chapter 23	Chapter 22
· describing matter as containing discrete positive and negative particles	23.1	23.1	22.1
· explaining electrical interactions in terms of the law of conservation of charge	23.3	23.3	22.3
· explaining electrical interactions in terms of the law of electric charge (two types of charge: like charges repel, unlike charges attract)	23.7	23.7	22.6
· comparing the methods of transferring charge: conduction and induction.	23.2, 23.5, 23.8	23.2, 23.5, 23.8	22.2, 22.4, 22.7

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
2. Coulomb's law relates electric charge to electric force.			
· Coulomb's law explains the relationships among force, charge and separating distance, by:	23.9	23.9	22.8
· explaining, qualitatively, the principles pertinent to Coulomb's torsion balance experiment			
· explaining, quantitatively, using Coulomb's law and vectors, the electrostatic interaction between discrete point charges	23.9 - 23.13	23.9 - 23.13	22.8 - 22.11
· comparing the inverse square relationship as it is expressed by Coulomb's law and Newton's universal law of gravitation	13.1, 23.9	13.1, 23.9	12.1, 22.8
3. Electric field theory is a model used to explain how charges interact.			
· the concept of field is applied to electric interactions, by extending from Physics 20, Unit 2, the definition of field, and by:	Chapter 24	Chapter 24	Chapter 23
· comparing scalar and vector fields			
· comparing forces and fields	13.10, 24.1	24.1	23.1
· explaining, quantitatively, using vector addition, electric fields in terms of intensity (strength) and direction relative to the source of the field	Chapters 24, 25, 26	Chapters 24, 25, 26	Chapters 23, 24
· explaining, quantitatively, using vector addition, electric fields in terms of intensity (strength) and direction relative to the effect on an electric charge	Chapter 24, 25	Chapter 24, 25	Chapters 23, 24
· predicting, using algebraic and/or graphical methods, the path followed by a moving electric charge in a uniform electric field, using kinematics and dynamics concepts	Chapter 24	Chapter 24	Chapter 23
· explaining electrical interactions, quantitatively, using the conservation laws of energy and charge.	Chapters 23 - 35	Chapters 23 - 34	Chapters 22 - 30
4. Electric circuits facilitate the use of electric energy.			
· Ohm's law and Kirchhoff 's rules are fundamental to explaining simple electric circuits, by:	Chapters 27, 29	Chapters 27, 29	Chapters 25, 27
· defining current, potential difference, resistance and power, using appropriate terminology	25.14, 27.1, 27.6, 27.13	25.11, 27.1, 27.3, 27.8	24.6, 25.1, 25.3, 25.7

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
· defining the ampere as a fundamental SI unit, and relating the coulomb and second to it	27.1	27.1	25.1
· distinguishing between conventional and electron flow current	27.1	27.1	25.1
· explaining Ohm's law as an empirical, rather than a theoretical, relationship	27.6	27.3	25.3
· quantifying electrical energy and power dissipated in a resistor, using Ohm's law	27.13 - 27.18	27.8 - 27.13	25.7 - 25.11
· explaining Kirchhoff 's current and voltage rules as a logical consequence of the laws of conservation of energy and charge	29.3, 29.17, 29.20	29.3, 29.17, 29.20	27.3
· analyzing, quantitatively, simple series and/or parallel DC circuits in terms of the variables of potential difference, current and resistance, using Kirchhoff 's rules and/or Ohm's law (solutions requiring Kirchhoff 's rules to be limited to networks containing two power supplies and three branch currents).	Chapters 27 - 29	Chapters 27 - 29	Chapters 25 - 27
Unit 3: Magnetic Forces and Fields			
1. Magnetic field theory is a model used to describe magnetic behaviour.			
· field theory can be used to describe magnetic interactions, by extending from Physics 20, Unit 1 and Physics 20, Unit 2, and by:	Chapter 30	Chapter 30	Chapter 28
· explaining the source of magnetic characteristics of matter in terms of magnetic domains	34.1	30.6	28.6
· comparing the magnetic properties of Earth with those of artificial magnets	30.1, 30.4	30.1, 30.4	28.1, 28.4
· explaining magnetic interactions in terms of vector fields	Chapters 30 - 32	Chapters 30 - 32	Chapters 28, 29
· comparing gravitational, electric and magnetic fields in terms of their sources and directions.	Chapters 13, 24, 26, 30 - 32	Chapters 13, 24, 26, 30 - 32	Chapters 23, 28, 29
2. Electromagnetism pervades the Universe.			
· magnetic forces and fields are described in relation to electric currents, by extending electromagnetic concepts from Science 9, Unit 4, and by:	Chapters 31 - 32	Chapters 31 - 32	Chapters 28, 29
· demonstrating how the discoveries of Oersted and Faraday form the foundation of the theory relating electricity to magnetism	31.0, 32.0	31.0, 32.0	29.0

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
· describing a moving charge as the source of a magnetic field; and predicting the orientation of the magnetic field from the direction of motion	Chapter 31	Chapter 31	28.20 - 28.22
· predicting, quantitatively, how a uniform electric and/or magnetic field affects a moving electric charge, using the relationships among charge, motion and field direction	24.10, 30.6	24.10, 30.7	23.8, 28.7
· relating and explaining, qualitatively, the interaction between a magnetic field and a moving charge as to how a magnetic field affects a current-carrying conductor	Chapter 32	Chapter 32	Chapter 29
· predicting, quantitatively, the effect of an external magnetic field on a current-carrying conductor	Chapter 32	Chapter 32	Chapter 29
· describing the effects of moving a conductor in an external magnetic field, using the analogy of a moving charge in a magnetic field	Chapter 32	Chapter 32	Chapter 29
· predicting, quantitatively, the effects of a magnetic field on a moving conductor	Chapter 32	Chapter 32	Chapter 29
· predicting, quantitatively, and verifying, the effects of changing one, or a combination, of the variables in the relationship Np/Ns = Vp/Vs = Is/Ip	32.23 - 32.24	32.20 - 32.21	29.15 - 29.16
· explaining the relationship between, and calculating, the effective and maximum values of, voltage and current in AC devices, given appropriate information	Chapter 33	Chapter 33	29.12 - 29.13
· discussing, qualitatively, Lenz’s law in terms of conservation of energy; describing, giving examples, situations where Lenz’s law applies.	32.14 - 32.16, 34.5	32.11 - 32.13	29.9
3. Electromagnetic radiation is a physical manifestation of the interaction of electricity and magnetism.			
· Maxwell’s theory of electromagnetism expanded on Oersted’s and Faraday’s generalizations, by:	Chapter 35	Chapter 34	Chapter 30
· stating that electromagnetic radiation is the result of accelerating electric charges, and demonstrates wavelike behaviour	35.2 - 35.8	34.2 - 34.5	30.2 - 30.5
· comparing and contrasting the constituents of the electromagnetic spectrum on the basis of frequency, wavelength and energy	35.1	34.1	30.1

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
· solving problems algebraically, using the relationships among speed, wavelength, frequency, period and/or distance, of electromagnetic waves	16.5 - 16.7	16.5 - 16.7	15.5 - 15.7
· comparing and contrasting natural and technological processes by which the major constituents of the electromagnetic spectrum are produced	35.1, 35.8	34.1, 34.5	30.1, 30.5
· explaining, qualitatively, Maxwell's theory of electromagnetism	35.2 - 35.7	34.2 - 34.4	30.2 - 30.4
· explaining the propagation of electromagnetic radiation in terms of perpendicular electric and magnetic fields, varying with time, travelling away from their source at the speed of light	35.2	34.2	30.2
· explaining, qualitatively, how different types of electromagnetic radiation interact with matter, including biological effects; e.g., microwaves, ultraviolet radiation, X-rays.	35.1	34.1	30.1
Unit 4: Nature of Matter			
1. The atom has an electric nature.			
· the discovery of the electron contributed to the formulation of quantum concepts and atomic models, by extending from Science 10, Unit 3, and by:	Chapters 42 - 44	Chapters 41 - 43	Chapters 36 - 38
· explaining how the discovery of cathode rays contributed to the development of atomic models	44.1	43.1	38.1
· explaining Thomson's experiment and the significance of the results	42.9	41.9	36.8
· deriving the relationship q/m = v/BR, using circular motion and charged particles in electric and magnetic field concepts	30.12	30.13	28.13
· explaining Millikan's experiment and its significance relative to charge quantization	42.9	41.9	36.8
· relating the electronvolt, as a unit of energy, to the joule.	25.15	25.12	24.7
2. The photoelectric effect requires the adoption of the photon model of light.			
· the quantum concept is required to explain adequately some natural phenomena, by extending from Physics 20, Unit 4, and by:	42.1	41.1	36.1
· explaining the necessity for Planck to introduce the quantum of energy concept to explain blackbody radiation	42.3 - 42.4	41.3 - 41.4	

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
· defining the photon as a quantum of electromagnetic radiation	42.4	41.4	36.3
· describing how Hertz discovered the photoelectric effect while investigating electromagnetic waves	42.6	41.6	36.5
· explaining the photoelectric effect in terms of the intensity and wavelength of the incident light and surface material	42.6	41.6	36.5
· assessing the assumptions made by Einstein in explaining the photoelectric effect	42.6	41.6	36.5
· defining threshold frequency as the minimum frequency giving rise to the photoelectric effect; and work function as the energy binding an electron to a photoelectric surface	42.6 ("cutoff frequency" used rather than "threshold")	41.6 ("cutoff frequency" used rather than "threshold")	36.5 ("cutoff frequency" used rather than "threshold")
· explaining the relationship between the kinetic energy of a photoelectron and stopping voltage			
· using Einstein's equation, quantitatively, to describe photoelectric emission	42.7	41.7	36.6
· describing the photoelectric effect as a phenomenon that supports the notion of the wave–particle duality of electromagnetic radiation	42.6	41.6	36.5
· explaining X-ray production as an inverse photoelectric effect, and predicting, quantitatively, the short wavelength limit of X-rays produced, given appropriate data			
· explaining, qualitatively, the Compton effect and the de Broglie hypothesis applying the laws of mechanics, conservation of momentum and energy, to photons, as another example of wave–particle duality.	43.1 - 43.8	42.1 - 42.8	37.1 - 37.4
3. Nuclear fission and fusion are nature's most powerful energy sources.			
· the processes of nuclear fission and fusion are nature's most powerful energy sources, by:	44.13, 44.14	43.13, 43.14	38.13 - 38.14
· using the isotope notation to describe and identify common nuclear isotopes, and determine the number of each nucleon of an atom	44.3	43.3	38.3
· describing the nature and behaviour of alpha, beta and gamma radiation	44.15	43.15	38.15
· writing nuclear equations for alpha and beta decay	44.16	43.16	

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
· performing simple, nonlogarithmic, half-life calculations	44.18 - 44.19	43.18 - 43.19	38.17
· predicting the particles emitted by a nucleus from the examination of representative transmutation equations	44.15 - 44.16	43.15 - 43.16	38.15
· explaining, qualitatively, how radiation is absorbed by matter, and compare and contrast the biological effects of different types of radiation			
· comparing and contrasting the characteristics of fission and fusion reactions	44.13 - 44.14	43.13 - 43.14	38.13 - 38.14
· explaining, qualitatively, the importance of Einstein's concept of mass–energy equivalence	44.9 - 44.14	43.9 - 43.14	38.9 - 38.14
· relating, qualitatively, the mass defect of the nucleus to the energy released in nuclear reactions.	44.9 - 44.14	43.9 - 43.14	38.9 - 38.14
4. Energy levels in nature support modern atomic theory.			
· the Rutherford–Bohr model of the atom represents a synthesis of classical and quantum concepts, by:	Chapters 42, 43	Chapters 41, 42	Chapters 36, 37
· explaining, qualitatively, the significance of the results of Rutherford's scattering experiment in terms of the nature and role of the nucleons; and the size and mass of the nucleus and the atom, which lead to the proposal of a planetary model of the atom	44.2	43.2	38.2
· explaining why Maxwell's theory of electromagnetism predicts the failure of a planetary model of the atom	42.9	41.9	36.8
· describing why each element has a unique line spectrum, and comparing and contrasting the characteristics of continuous and line spectra	42.2, 42.9 - 42.12	41.2, 41.9 - 41.11	36.2, 36.8 - 36.9
· explaining, qualitatively, the conditions necessary to produce line emission and line absorption spectra	42.2	41.2	36.2
· explaining the quantum implications of the line absorption and the line emission spectra, and determining any variable in the Balmer equation 1/λ - RH(1/nf^2 - 1/ni^2)	42.2	41.2	36.2

	Physics for Scientists and Engineers	Principles of Physics	Conceptual Physics
· explaining Bohr's concept of "stationary states" and their relationship to line spectra of atoms; and using the frequency/wavelength of an emitted photon to determine the energy difference between states	42.9, 42.12	41.9, 41.11	36.8, 36.9
· explaining the relationship between hydrogen's absorption spectrum and its energy levels	42.9	41.9	36.8
· describing how the Bohr atom can be used to predict the ionization energy of hydrogen, and to calculate the allowed radii of the hydrogen atom	42.10	41.10	
· describing how the Rutherford–Bohr model has been further refined, by applying quantum concepts to a purely mathematical model based on probability and waves	43.8 - 43.16	42.8 - 42.11	37.4 - 37.6
· comparing and contrasting, qualitatively, the Rutherford, the Bohr and the quantum model of the atom.	Chapters 42, 43	Chapters 41, 42	Chapters 36, 37