Category	Topic	Concept	Definition	Exclusion	Examples
Explicit particle physics	**Cosmology**	**Big Bang**	Curriculum mentions Big Bang or the beginning of the Universe.		"The Big Bang Theory describes the early development of the universe including the formation of subatomic particles from energy and the formation of atomic nuclei."
		Inflation	Curriculum mentions the inflation of the early Universe.		"After the Big Bang, the Universe expanded exponentially for a few fractions of a second. This period is called inflation."
		Expansion	Curriculum mentions the continuous expansion of the Universe or the red shift.		"In the line spectra of distant stars we can see a shift towards longer wavelengths, which shows that the Universe is expanding."
	Standard Model of particle physics	**Standard Model of particle physics**	Curriculum explicitly mentions the Standard Model of particle physics.		"Students learn about the Standard Model of particle physics."
	Fundamental interactions	**Electromagnetic interaction**	Curriculum mentions at least one of the following: electromagnetic force or electromagnetic interaction (in the context of particle physics), electric charge (in the context of particle physics), photon (as an interaction particle for electromagnetic interaction).		"The Standard model explains three of the four (strong, weak and electromagnetic forces) in terms of an exchange of force-carrying particles called gauge bosons."
		Strong interaction	Curriculum mentions at least one of the following: strong interaction, strong nuclear force, strong force (as a nomenclature for this particle interaction), colour force, gluons.		"The Standard model explains three of the four (strong, weak and electromagnetic forces) in terms of an exchange of force-carrying particles called gauge bosons."
		Weak interaction	Curriculum mentions at least one of the following: weak interaction, weak nuclear force, weak force (as a nomenclature for this particle interaction), W & Z bosons.		"The Standard model explains three of the four (strong, weak and electromagnetic forces) in terms of an exchange of force-carrying particles called gauge bosons."
		Gravity in the context of particle physics	Curriculum mentions at least one of the following: gravity (in the context of particle physics), gravitational force (in the context of particle physics), gravitational interaction (in the context of particle physics), graviton.	To code gravity in classical or relativistic context, please use the codes "Newtonian gravity" or "Einsteinian gravity".	"The Standard model does not yet include gravity and its hypothetical gauge boson graviton."
	Charges	**Electric charge**	Curriculum mentions electric charge.		"The students get to know three types of charges: strong, weak, and electric."
		Strong charge	Curriculum mentions strong charge or colour charge.		
		Weak charge	Curriculum mentions weak charge.		
	Elementary particles	**Quarks**	Curriculum mentions quarks or at least one of the following: up quark, down quark, strange quark, charm quark, top quark, bottom quark, anti-(up quark, etc.).		"Compare and contrast the up quark, the down quark, the electron and the electron neutrino, and their antiparticles, in terms of charge and energy (mass-energy)."
		Leptons	Curriculum mentions leptons or at least one of the following: electron, muon, tauon, neutrino, electron neutrino, muon neutrino, tauon neutrino, anti-(electron, muon, etc.).		"Compare and contrast the up quark, the down quark, the electron and the electron neutrino, and their antiparticles, in terms of charge and energy (mass-energy)."
	Interaction particles	**Bosons**	Curriculum mentions bosons or at least one of the following: photons (as interaction particles), W bosons, Z bosons, gluons, gauge bosons.	To code Higgs boson, please use code "Brout-Englert-Higgs mechanism".	"The Standard Model explains three of the four (strong, weak and electromagnetic forces) in terms of an exchange of force-carrying particles called gauge bosons."
	Brout-Englert-Higgs mechanism	**Brout-Englert-Higgs mechanism**	Curriculum mentions at least one of the following: Brout-Englert-Higgs mechanism, Higgs mechanism, Brout-Englert-Higgs field, Higgs field, interaction of particles with the Brout-Englert-Higgs field through which the particles can gain mass, Higgs boson or Higgs particle.		"Particles gain mass through interaction with the Brout-Englert-Higgs field. This mechanism is called the Brout-Englert-Higgs mechanism."
	Particle transformations	**Particle transformations**	Curriculum mentions at least one of the following: particle transformation, particle decay, beta decay, alpha decay, particle annihilation, pair production.		"Students learn about the types of transformations that are allowed by the Standard Model."
	Feynman diagrams	**Feynman diagrams**	Curriculum mentions at least one of the following: Feynman diagrams, particle interaction diagrams, reaction diagrams (in the context of particle physics).		"Reactions between particles can be represented by simple reaction diagrams."
	Antimatter research	**Antimatter research**	Curriculum mentions at least one of the following: antiparticles, antiquarks, anti-(up quark, …, muon, …), positron, annihilation, beta+ decay, positron emission, positron emission tomography, antimatter, the mystery of antimatter, anti-hydrogen, antimatter research, matter-antimatter asymmetry, baryon asymmetry, etc.		"Compare and contrast the up quark, the down quark, the electron and the electron neutrino, and their antiparticles, in terms of charge and energy (mass-energy)."
	Particle accelerator	**Linear accelerator**	Curriculum mentions at least one of the following: linear particle accelerator, linear accelerator, linac. Curriculum can also mention specific examples: SLAC, etc.		"Particle accelerators can accelerate particles in a straight line (linear accelerators) or a circle (circular accelerators)."
		Circular accelerator	Curriculum mentions at least one of the following: circular particle accelerator, synchrotron, particle collider. Curriculum can also mention specific examples: LHC, Tevatron, HERA.		"Magnetic fields and the Lorentz force are the key to mass spectrometers and circular particle accelerators. "
		Particle accelerator (unspecified type)	Curriculum mentions particle accelerators without specifying the type of the particle accelerator.	Use this code for all mentions of particle accelerators that do not fit under codes "Linear accelerators" and "Circular accelerators".	"High-energy particle accelerators are used in particle physics research to create and observe particles."
	Particle detector	**Historical particle detectors**	Curriculum mentions at least one of the following: historical particle detectors, cloud chamber, bubble chamber, spark chamber, Geiger-Müller tube (or counter).		"Positron was discovered in 1932 by Carl Anderson, using a cloud chamber."
		Modern particle detectors	Curriculum mentions modern particle detectors. Curriculum can also mention specific examples: ATLAS, CMS, ALICE, CDF, ZEUS, AMS, Super-Kamiokande etc.		"Similar principles of detection as in cloud chambers are also used in modern particle detectors (e.g. ATLAS at CERN). However, the techniques there are different."
		Particle detector (unspecified type)	Curriculum mentions particle detectors without specifying the type or an example of the detector.	Use this code for all mentions of particle detectors that do not fit under codes "Historical particle detectors" and "Modern particle detectors".	"The laws of relativistic mechanics are routinely used in order to manage the operation of nuclear power plants, particle accelerators and particle detectors."
	Data storage and data analysis	**Data storage and data analysis**	Curriculum mentions at least one of the following in the context of modern (particle) physics: data, big data, statistical methods, statistical tools, sigma, signal, data analysis, analysis, measurements, background (in the context of particle physics measurements), data storage, big data, magnetic strip tape, www, internet, cloud, data centre.		"Explain how the analysis of particle tracks contributed to the discovery and identification of the characteristics of subatomic particles."
	Advances in particle physics	**Latest experimental results**	Curriculum encourages teachers to keep up with the latest experimental results in particle physics.		"Students must be familiar with the main results of CERN, Fermilab, etc."
		Open questions	Curriculum mentions at least one of the following: supersymmetry, string theory, dark matter, dark energy, the limitations of the Standard Model, the limitations of the Big Bang theory, baryon asymmetry, matter-antimatter asymmetry, grand unifying theory, quantum gravity.		"Matter only represents 5% of the Universe, while 27 % is represented by dark matter and 68 % by dark energy."
	Real-life applications of particle physics	**Real-life applications of particle physics**	Curriculum mentions at least one of the following in the context of particle physics: medical applications, medical accelerators, hadron therapy, proton therapy, positron emission tomography (PET scan), radiation therapy, X-rays, World Wide Web, touchscreens, modern technology, computer science, material science, cryogenics, security scans, solenoid magnets, superconductors, data processing devices.	Do not use this code if the application is used only as a tool for teaching and not as a context or content for teaching.	"Discuss various technologies that stemmed from modern physics research (medical detectors, security detectors, world wide web, touchscreens, etc.)"

Category	Topic	Concept	Definition	Exclusion	Examples
Other curricular topics	**Mechanics**	**Linear motion**	Curriculum mentions linear motion, straight line motion or rectilinear motion.		"Use of calculus methods to calculate instantaneous displacement, velocity and acceleration for **straight line motion** with a constant or varying acceleration."
		Circular motion	Curriculum mentions circular motion or angular motion.		"Introduction to **angular motion** by considering the rotational equivalents of displacement, velocity and acceleration."
	Gravity	**Newtonian gravity**	Curriculum mentions at least one of the following: gravity, gravitational force, gravitational interaction.	To code gravity in the context of particle physics, please use the code "Gravity (in the context of particle physics)".	"All objects with mass attract one another with a **gravitational force**."
		Einsteinian gravity	Curriculum mentions at least one of the following: curvature of space-time, general relativity, general theory of relativity, gravitational lensing.		"Einstein's great achievement, the **general theory of relativity**, is based on intuition, creative thinking and imagination."
	Conservation laws of	**Energy**	Curriculum mentions conservation of energy, regardless of the type of energy that is being conserved.		"**Conservation of** linear momentum and **energy** in collisions."
		Linear momentum	Curriculum mentions conservation of momentum in the context of linear momentum.		"**Conservation of linear momentum** and energy in collisions."
		Angular momentum	Curriculum mentions conservation of angular momentum.		"Use of the principle of **conservation of angular momentum** to solve problems."
		Charges	Curriculum mentions conservation of charges.		"Explain electrical interactions in terms of the law of **conservation of charge**."
	Thermo-dynamics	**Particle model in thermodynamics**	Curriculum mentions at least one of the following: the particle model of matter (in the context of thermodynamics), the kinetic theory of gasses, particle model of ideal gas.		"Explain temperature, using kinetic energy and the **particle model of matter**."
		Phase transitions	Curriculum mentions any of the phase transitions or phase transitions in general.		"Explain **changes of state** using the particle model."
		Vacuum	Curriculum mentions vacuum. Do not code unless vacuum is explicitly mentioned in the curriculum.		"Heat insulators (e.g. **vacuum**)."
	Electro-magnetism	**Electric fields**	Curriculum mentions the homogeneous or non-homogeneous electric fields, or interaction between electric field and particles.		"Use of appropriate relationships to solve problems involving the **motion of charged particles in uniform electric fields**."
		Magnetic fields	Curriculum mentions the interaction between homogeneous or non-homogeneous magnetic field and particles.	Do not code for interactions of magnetic field with a conducting wire.	"Analyse, qualitatively and quantitatively, **the forces acting on a moving charge** and on an electric current **in a uniform magnetic field**."
		Magnetic force	Curriculum mentions the magnetic force or one of its synonyms, for example: Lorentz force, Fleming law, right-hand rule, left-hand rule, etc.		"For positive charges, students should use a **right-hand rule**."
		Ionisation	Curriculum mentions ionisation.		"Demonstration of **ionisation** and penetration by the radiations using any suitable method, e.g. electroscope."
		Electromagnetic waves	Curriculum mentions electromagnetic waves.		"**Electromagnetic waves** are transverse waves made up of mutually perpendicular, oscillating electric and magnetic fields."
		Superconductivity	Curriculum mentions superconductors, either as main content or an example.		"**Superconductivity** is the phenomena observed when materials are cooled below a characteristic temperature, and zero electrical resistance occurs."
	Radiation	**Cosmic radiation**	Curriculum mentions at least one of the following: the origins, the properties, the detection of cosmic rays, history of the detection of cosmic rays.	To code radiation or background radiation in general, please use the code "Radiation".	"Knowledge of the origin and composition of **cosmic rays**, the interaction of cosmic rays with Earth's atmosphere."
		Radioactivity (Alpha)	Curriculum mentions at least one of the following: alpha radioactivity, alpha decay, alpha particle.		"Some nuclides are unstable and spontaneously decay, emitting **alpha**, beta and/or gamma radiation over time until they become stable nuclides."
		Radioactivity (Beta)	Curriculum mentions at least one of the following: beta radioactivity, beta decay, beta minus, beta plus, electron capture, beta ray.		"Some nuclides are unstable and spontaneously decay, emitting alpha, **beta** and/or gamma radiation over time until they become stable nuclides."
		Radioactivity (Gamma)	Curriculum mentions at least one of the following: gamma ray, gamma radioactivity, gamma decay.		"Some nuclides are unstable and spontaneously decay, emitting alpha, beta and/or **gamma** radiation over time until they become stable nuclides."
		Radiation in general	Curriculum mentions at least one of the following; ionising radiation, radioactive sources, radiation protection, background radiation, radioactive decay.	Use this code for all mentions of radiation that do not fit under codes "Cosmic radiation", "Radioactivity (Alpha)", "Radioactivity (Beta)", and "Radioactivity (Gamma)".	"The law of **radioactive decay** and the decay constant."
	Special relativity	**Relativistic motion**	Curriculum mentions relativistic motion or its effects, such as time dilation and contraction of space-time.	Use this code only for motion at speeds close to the speed of light. For relative motion, you can use either "Linear motion" or "Circular motion", depending on the type of motion.	"Observations of objects travelling at very high speeds cannot be explained by Newtonian physics (for example, the **dilated half-life** of high-speed muons created in the upper atmosphere)."
		$E=mc^2$	Curriculum mentions at least one of the following: $E=mc^2$, $E=\gamma mc^2$, $E=\sqrt{(m^2c^4+p^2c^2)}$, invariant mass, mass-energy equivalence.		"Special relativity leads to the idea of **mass-energy equivalence**, which has been applied in nuclear fission reactors."
	Quantum physics	**Quantum effects**	Curriculum mentions at least one of the following: (quantum) tunnelling, (quantum) entanglement, non-locality, the EPR experiment.		"The uncertainty principle in terms of energy and time leads to the concept of **quantum tunnelling**."
		Probability in quantum physics	Curriculum mentions at least one of the following: uncertainty principle, Heisenberg's principle, wave-particle duality, Schrödinger equation, wave nature of particles, the double-slit experiment, wave model of matter, electron diffraction, de Broglie wavelength.		"Use of an appropriate relationship to solve problems involving the **de Broglie wavelength of a particle and its momentum**."
		Atomic models	Curriculum mentions at least one of the following: atomic model, the atomic orbital model, electron cloud, atomic theory, Bohr atomic model.		"Explain how the discovery of cathode rays contributed to the development of **atomic models**."
		Atomic energy levels	Curriculum mentions at least one of the following; discrete energy levels in an atom, atomic energy levels, line spectrum.		"Describe that each element has a unique **line spectrum**."
		Quantum mechanics	Curriculum mentions at least one of the following: quantum physics, quantum mechanics, quantum theory.	Use this code for all mentions of quantum physics that do not fit under codes "Quantum effects", "Probabilistic nature of quantum physics", "Atomic models", and "Atomic energy levels".	"**Quantum theory** can be introduced by consideration of experimental observations that could not be explained by classical physics."

Category	Topic	Concept	Definition	Exclusion	Examples
History and Nature of Science	**History of physics**	**History of quantum physics**	Curriculum mentions the historical developments of quantum physics, for example: the atomic model, wave-matter duality etc.	To code historical findings of fundamental interactions or elementary particles, please use the code "History of particle physics".	"To the long-held hypothesis that light is a wave, Einstein added the photon hypothesis of light as a possible explanation of the photoelectric effect. This was one of the many steps in a historical paradigm shift which eventually led to the development of quantum physics."
		History of particle physics	Curriculum mentions discoveries of quarks, bosons, leptons (apart from electron), Higgs bosons etc. and strong and weak interactions.		"Paul Dirac predicted anti-matter mathematically."
	Nature of Science	**Nature of Science**	Curriculum mentions at least one of the following: the function and limitations of models, the tentative and changing nature of science, the role of hypothesis and observations, various controversies in science, and the societal impacts of science.		"Students appreciate and value the understanding that science operates with the consent of personal, social, political, environmental, and multicultural orientations of the global society."