A History of the science of light from Galileo’s telescope to the laser and the quantum information revolution

1. **Light in the seventeenth and eighteenth centuries:**
   - How the invention of the telescope and the pendulum has started the scientific revolution. The roles of Galileo and Huygens.
   - First determination of light’s velocity by Römer’s observation of Jupiter’s moons
   - Snell and Descartes.
   - Fermat and the principle of least time.
   - Huygens and the emergence of the wave theory.
   - Newton, the emission theory and the spectrum of light.
   - The aberration of stars.
   - Connection between optics and the exploration of the Earth: the measure of the meridian and the oblateness of the planet.

2. **Light in the nineteenth century:**
   - Thomas Young and interferences
   - Malus and the polarization of light
   - Fresnel, the diffraction theory and the vector model of light’s vibrations
   - Fourier and spectral analysis
   - Measurement of light velocity in air and in a medium: Fizeau and Foucault
   - The birth of electromagnetism: Oersted, Ampère and Faraday
   - The notion of field
   - Maxwell’s equations
   - What was known about light at the end of the nineteenth century

3. **The first cloud of Lord Kelvin: Relativity**
   - The Ether puzzle
   - Michelson Morley experiment
   - The principle of special relativity: from Galileo to Einstein
   - Relativity of simultaneity
   - Relativity of time and lengths
   - The twin paradox
   - Lorentz transformations
   - Minkowsky four-dimensional space
   - $E=mc^2$
   - The principle of equivalence and general relativity
   - The curvature of space-time
   - The proofs of relativity

4. **The second cloud of Lord Kelvin: quantum physics**
   - The puzzle of blackbody radiation and Planck’s law
   - Einstein, the photoelectric effect and the photon
   - How the quanta extended to matter: the heat capacity of solids
   - The planetary model of the atom: Rutherford, Bohr and Sommerfeld
   - Einstein and stimulated emission
   - The Bose Einstein statistics and the identity of particles
- Bosons and fermions
- De Broglie and matter waves
- Schrödinger, Heisenberg, Dirac and Feynman: the modern quantum theory.

5. **The principles of quantum physics**
   - The Superposition principle
   - Measurement and complementarity
   - Uncertainty relations
   - Discussion of thought experiments
   - Entanglement and non-locality
   - Bell’s inequalities
   - The quantum-classical limit: Feynman’s diagrams
   - Decoherence theory

6. **The first quantum revolution in technology**
   - Discovery of the spin: the Stern Gerlach experiment
   - Rabi and the molecular beam method
   - Nuclear magnetic resonance
   - Magnetic resonance imaging
   - The atomic clock
   - The GPS
   - Optical pumping
   - The invention of the laser

7. **The laser revolution**
   - The precision revolution: high resolution spectroscopy
   - The sensitivity revolution: manipulating single particles
   - The light intensity revolution: Non-linear optics
   - Ultra-short pulses and ultra-high intensities: extreme light

8. **Laser cooling and trapping**
   - Principle of Doppler cooling
   - Sub-Doppler cooling
   - Optical tweezers and optical lattices
   - Magnetic traps
   - Atomic interferometry
   - Evaporative cooling
   - Degenerate quantum gases

9. **Ion trapping**
   - Principle of ion trapping
   - Ion manipulation
   - Ion quantum jumps
   - Laser cooling of ions
   - Ions as quantum bits
   - Quantum information with trapped ions
10. The physics of Rydberg atoms
   - Orders of magnitude
   - Preparation and detection of Rydberg atoms
   - Rydberg atom spectroscopy
   - Interaction between Rydberg atoms
   - Applications of Rydberg atoms to quantum information

11. Cavity quantum electrodynamics
   - Coupling two-level atoms to a cavity field mode
   - Enhancement and suppression of spontaneous emission: the Purcell factor
   - The Jaynes Cummings model
   - Vacuum Rabi oscillation
   - Quantum information in Cavity QED
   - Realizing thought experiment in Cavity QED

12. Quantum non-demolition experiments:
   - Detecting photons without destroying them: the principle of QND methods
   - QND Photon counting illustrating a quantum measurement
   - Tomographic reconstruction of quantum states
   - Quantum feedback experiments
   - Quantum Zeno experiments

13. Schrödinger cat states and decoherence studies
   - Preparation of quantum state superpositions by dispersive methods
   - Preparation of cat states by resonant methods
   - Experimental study of decoherence
   - Comparing Cavity QED, circuit QED and ion trap physics

14. Quantum metrology
   - Principle of quantum metrology
   - The standard quantum limit
   - Sensitivity beyond the standard quantum limit: squeezed states
   - Sensitivity beyond the standard quantum limit: Entangled sates
   - Quantum electrometers and magnetometers

15. Conclusion: coming back to the history of time measurement
   - The importance of precise time measurement, from Huygens to the lasers
   - The gain in precision from the 17th to the 20th century
   - The optical clocks
   - Frequency combs
   - Ion clocks versus neutral atom lattice clocks
   - Relativity tests
   - Cosmology tests
   - General conclusion of lectures.