

Exam 1 Outline

Chapters 2–4

Chapter 2: Relativity

- Inertial reference frame
- Laws of physics is the same in all inertial reference frames
- No such thing as “absolute rest”
- The speed of light is the same in all reference frames.
- Why was the ether theory proposed, and how was it ruled out?
- What is the Michelson-Morley experiment?
- What is an event?
- What is a worldline?
- What do I mean by a $c = 1$ system? How are lengths measured in such a system?
- $t - x$ graphs to show worldlines. Be able to interpret them. What does slope represent?
- No object or information can travel faster than the speed of light.
- Simultaneous events are not simultaneous in all frames.
- Time dilation
- Length contraction (in direction of motion only)
- How do muons demonstrate special relativity (in the muon’s frame and in the Earth’s frame?)
- What is γ ?
- Lorentz transformations
- Velocity addition
- Light cones, spacelike and timelike relationships
- What is the spacetime interval? What’s special about it? How is it calculated?
- What is proper time? How is it calculated?
- Describe and resolve the twin paradox
- Relativistic momentum, energy, and kinetic energy
- What is rest mass?
- What is the momentum of a massless particle?
- Relativistic Collision problem
- Relativistic Doppler effect
- Time dilation in an accelerating frame
- Gravitational vs inertial mass
- What is the key concept in general relativity?
- Time dilation in a gravitational field
- Gravity warps space, deflects light

Chapter 3: Light as Particles

Blackbody Radiation

- What is a blackbody? Give some examples?
- Explain the ultraviolet catastrophe. Explain Planck's solution.
- What does dU/df signify when referring to the blackbody?

Photoelectric Effect

- Describe the photoelectric effect.
- What is the work function?
- Explain why the wave model of light doesn't work.
- What is a photon?
- What do frequency and intensity of light correspond to in a photon model?
- What is the maximum kinetic energy of the released electrons?

Bremsstrahlung

- Describe bremsstrahlung.
- Why doesn't the wave model of light work for it?
- What is the minimum wavelength of the X-rays emitted?

Compton Effect

- Describe the Compton effect. How does the wavelength vary?
- Why does the wave model of light fail to describe the effect?
- Use the equation $\lambda' - \lambda = \frac{h}{mc}(1 - \cos \theta)$.
- Be able to explain the collision problem.

Pair Production and Annihilation

- Explain what happens when a particle and its antiparticle annihilate each other.
- Explain what happens when a photon produces a particle and antiparticle? Why can't this happen in isolation?

Wave vs Particle

- When does light act like a wave, and when like a particle?
- What does an interference pattern (in a double-slit experiment, for instance) tell you about the pattern of individual photons?

Chapter 4: Matter as Waves

- What is the de Broglie wavelength of a particle? The frequency?
- What does $\Psi(x, t)$ represent? $|\Psi|$?
- Describe an experiment that demonstrated that electrons behave as waves.
- What are k and ω ? How are they related to λ , f , p , and E ?
- \hbar
- Group velocity and phase velocity
- Forceless Schrodinger's equation, and its solution
- Plane waves
- Why should $\int |\Psi|^2 dx = 1$?
- The Schrodinger equation is linear—what does that mean?
- How do we calculate the uncertainty in a variable?
- What is Heisenberg's uncertainty principle?
- An electron circling a proton is accelerating, and accelerating charges will lose energy. Why are hydrogen atoms stable?
- What is the underlying quantum assumption of the Bohr model of hydrogen? What are the results of the Bohr model? How do we know that it's true, experimentally?
- What does $\Delta E \Delta t \geq \frac{\hbar}{2}$ really mean? Give a couple examples.
- Understand what we mean when we write $\psi(x) = \int A(k)e^{ikx} dk$. What is $A(k)$ called and how is it calculated?