Indian Institute of Technology Guwahati

Tutorial-6 PH131: Modern Physics Due on: 11 November 2025

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1. (a) Use the relativistic relation between energy and momentum, and hence find the wavelengths (de Broglie wavelength) of electron and photons at the three different kinetic energy, 1 keV, 1 MeV and 1 GeV.
   (b) Find the phase velocity and group velocity of the de Broglie wave of an electron whose speed is $v = 0.9c$. (Hint: De Broglie phase velocity is c^2/v and group velocity is same as the velocity of the particle.)

2. A proton in a one-dimensional box has an energy of 400 KeV, in its first excited state. How wide is the box?

3. Show using the uncertainty principle that the minimum possible kinetic energy also called the zero point energy for a quantum particle (of rest mass m_0) confined in a region of width a is $K_{av} = \frac{\hbar^2}{2m_0a^2}$. (Hint: Use the uncertainty relation $\Delta x\,\Delta p \geq \frac{\hbar}{2}$)

4. A long lived unstable atomic state has a lifetime of one millisecond. Roughly, what is the minimum uncertainty in its energy? Assuming that photon emitted when this state decays is visible at λ=550 nm, what are the uncertainty and fractional uncertainty in its wavelength ? (Hint: Use the uncertainty relation $\Delta t\,\Delta E \geq \frac{\hbar}{2}$)
