

Relativity, laboratory methods and specialised topics

GRE · GRE Subject Test · GRE Physics

A precise instrument can give consistently wrong results when its calibration is shifted.

Prerequisites: 21, 22, 42, 43, 44.

- Apply special-relativistic energy and spacetime relations
- Propagate measurement uncertainty and analyse experimental data
- Recognise nuclear, particle, condensed-matter and astrophysical concepts

Choose the system and model

Special relativity uses $\gamma=1/\sqrt{1-v^2/c^2}$. Rest energy is mc^2 and total energy is γmc^2 .

Use the governing relation

For independent small uncertainties, combine contributions in quadrature; correlated uncertainties require covariance terms.

Apply the conditions

Random scatter affects precision; calibration bias affects accuracy. A log plot can reveal a power law.

Check the conclusion

Nuclear, particle, condensed-matter and astrophysics questions require undergraduate vocabulary and models. School physics alone is not a complete preparation course.

Worked method

Proper time is measured between events at one position in a frame. For a particle speed $0.60c$,

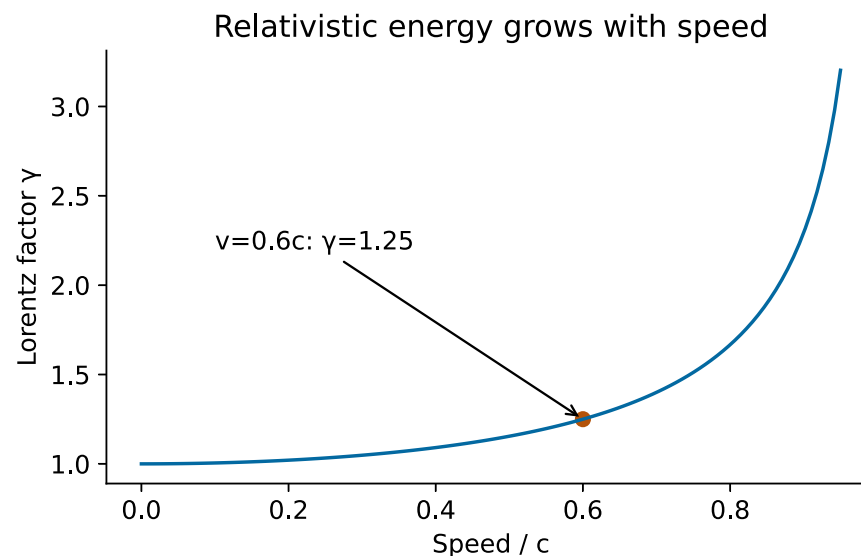
$$\gamma = (1 - v^2/c^2)^{-1/2} = (1 - 0.60^2)^{-1/2} = 1.25.$$

If its mean proper lifetime is 4.0 microseconds,

$$\tau = \gamma\tau_0 = 1.25(4.0\ \mu\text{s}) = 5.0\ \mu\text{s}.$$

$$\bar{d} = v\tau = (0.60)(3.00 \times 10^8\ \text{m/s})(5.0 \times 10^{-6}\ \text{s}) = 900\ \text{m}.$$

A lifetime is a mean of a distribution; it does not predict an individual decay time.



Relativity, laboratory methods and specialised topics: original GRE teaching diagram.

Check conditions and vocabulary

Adding percentage uncertainties linearly gives a worst-case bound, not the independent statistical standard uncertainty.

precision: Closeness of repeated measurements to each other.

covariance: A measure of joint variation used for correlated uncertainties.