

Relativity, laboratory methods and specialised topics

GRE undergraduate preparation · local supported objectives

Choose the physical question

Reasoning

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

Reasoning

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

Reasoning

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

Apply the conditions

Reasoning

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

Check the conclusion

Reasoning

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

Worked reasoning 1

Reasoning

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

Worked relation 2

Reasoning

Apply this relation only under the conditions just stated.

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

Worked reasoning 3

Reasoning

If its mean proper lifetime is 4.0 microseconds,

Worked relation 4

Reasoning

Apply this relation only under the conditions just stated.

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

Worked relation 6

Reasoning

Apply this relation only under the conditions just stated.

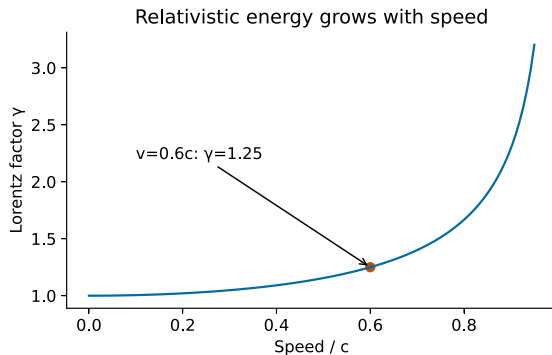
$$\bar{d} = v\tau = (0.60)(3.00 \times 10^8 \text{ m/s})(5.0 \times 10^{-6} \text{ s}) = 900 \text{ m}.$$

Worked reasoning 7

Reasoning

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

Read the original diagram



- Original GRE teaching diagram: Relativity, laboratory methods and specialised topics
- Identify the axes, units, directions and the stated model.

Independent transfer · attempt

Reasoning

A detector measures 400 independent radioactive counts in a fixed interval. State the Poisson standard uncertainty. How many times longer must it count to halve relative counting uncertainty at the same stable rate? Explain whether this change removes a constant calibration bias. **[4]**

Independent transfer · reasoning

Reasoning

$\sigma_N = \sqrt{N} = 20$ counts, relative uncertainty $1/\sqrt{N} = 0.05$. Half that relative uncertainty needs four times N , hence four times the interval. Repetition reduces random counting uncertainty, not constant calibration bias. Award absolute uncertainty, relative uncertainty, time factor and bias distinction.

Check assumptions and limits

Reasoning

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

Keep the technical distinctions

Reasoning

precision : Closeness of repeated measurements to each other. covariance
: A measure of joint variation used for correlated uncertainties.

Check yourself

- Define precision and give its condition of use.
- Define covariance and give its condition of use.
- Redo the original transfer with a changed parameter; check a limiting case.