

6.1 Relativity, laboratory methods and specialised topics

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS precision • covariance

Objective

Apply special-relativistic energy and spacetime relations; Propagate measurement uncertainty and analyse experimental data; Recognise nuclear, particle, condensed-matter and astrophysical concepts. Original public practice; not an ETS paper.

1 Key knowledge and worked examples

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

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

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

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 $0.60c$,

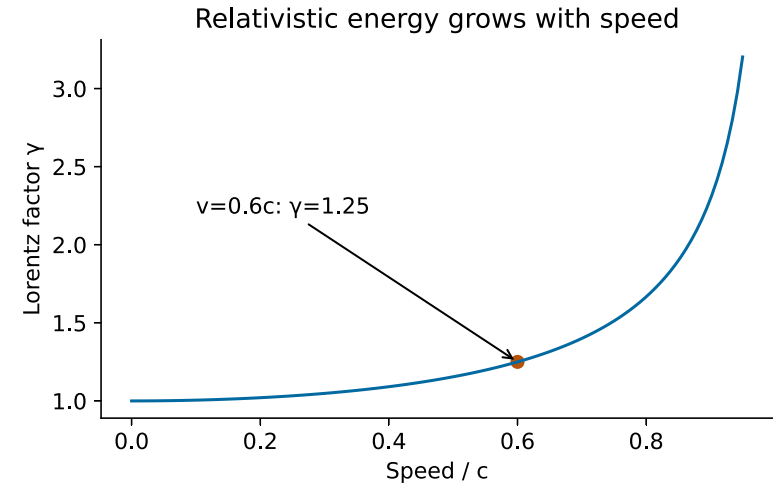
$$\gamma = (1 - v^2/c^2)^{-1/2} = (1 - 0.60^2)^{-1/2} = 1.25.$$

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.



2 Practice

2.1 Choose one answer. At $v=0$, the Lorentz factor is: [1]

- A 0
- B 1
- C infinite

2.2 Choose one answer. A fixed zero-offset error chiefly affects: [1]

- A accuracy
- B sample count
- C the definition of velocity

2.3 Independent relative uncertainties 6% and 8% combine to ____%. Show your relation and units. [2]

[2]

[4]