

Exam Template — Course X

Department of Physics — University Y

Course: General Topic

Semester 2026-1

Name: _____ ID Number: _____ Programme: _____

1. Generic Problem in Relativistic Mechanics (30 pt).

State the general context of the problem here.

- a) Derive a symbolic expression for a physical quantity of interest.

Solution:

This is a sample solution. Replace this text with the actual derivation.

Discuss the physical interpretation of the previous result and its limiting cases.

Solution:

Include a brief interpretation and a discussion of limiting cases here.

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2. Generic Problem in Electromagnetic Fields (40 pt).

Consider a scenario with fields \vec{E} and \vec{B} under a Lorentz transformation.

- a) Determine the fields in a moving reference frame and compare with the original frame.

Solution:

Write the transformation equations and a qualitative comparison of results here.

3. Single-Answer and Multiple-Answer Questions (30 pt).

Select the correct option(s) and provide a brief justification.

- a) **(Single Choice)** For a free particle, the conserved quantity associated with time-translation symmetry is:

a) The total angular momentum.

c) The effective electric charge.

b) The total energy.*

d) The local scalar curvature.

- b) **(Multiple Choice)** In special relativity, which of the following statements are correct?

a) The speed of light in vacuum is invariant.*

c) Events simultaneous in one frame may not be simultaneous in another.*

b) Proper time is the same for all inertial observers.

d) Rest mass depends on the reference frame.

4. Short Conceptual Questions (30 pt).

Answer briefly and with justification.

- a) **General Concepts** Describe in two or three sentences the difference between invariant quantities and observer-dependent quantities.

Solution:

An invariant keeps its value under Lorentz transformations, whereas an observer-dependent quantity changes with the reference frame.

- b) **Application** Propose an example where the choice of reference frame simplifies the analysis of a problem.

Solution:

A typical example is working in the centre-of-mass frame for relativistic collisions, which simplifies the conservation of energy and momentum.

Formula Sheet

- Euler–Lagrange equations: $\frac{d}{dt} \left(\frac{\partial L}{\partial \dot{q}_i} \right) - \frac{\partial L}{\partial q_i} = 0$
- Lagrange–Jacobi identity and Virial theorem: $\dot{G} = 2K + U, 2\langle K \rangle = -\langle U \rangle$
- Lorentz transformations (1D): $x' = \gamma(x - vt), \quad t' = \gamma \left(t - \frac{vx}{c^2} \right)$