

General Instructions

Theoretical exam (30 points)

July 8, 2026

Failure to comply with any of the following rules may result in disqualification. The theory exam lasts 5 hours and is worth a total of 30 points. The beginning and end of the exam will be indicated by an announcement, as well as every hour, indicating the time elapsed. This will also be done thirty, fifteen and five minutes before the end of the exam.

Before the Test

Do not open the envelopes until instructed. The following items are provided for use at the table: (1) a pen, (2) a scientific calculator, (3) a ruler.

During the exam

- Use the supplied pen to answer the questions.
- Use the answer sheets for your final answers. Fill in the appropriate sections with your answers and necessary observations. You should write only on the front side of the paper. Any writing on the back (reverse) side of the paper will not be scanned and will not be marked by the graders.
- Blank worksheets labeled with the heading **WORKSHEET** are provided for calculations. Use only the designated worksheets for this purpose. Cross off unnecessary answers and drafts that shouldn't be graded with an X. **Use only the front of each sheet and keep the margin off the edge clean. The back side of the pages will not be scanned and their contents will not be considered.**
- Answers should be concise and readable. Use equations, logic operators, symbols, and schematics to express your ideas clearly. Avoid using explanatory texts, as markers may not be multilingual. **You are not required to use every variable given to express your answer.**
- You do not need to quantify the uncertainty of your answers unless otherwise noted.
- Do not leave your post without permission. If you need any help (going to the bathroom, getting water, etc.), lift the paddle with the "Help" sign.

At the end of the exam

- Stop writing immediately when the end of the exam is announced.
- Place all the sheets in the envelope provided. Arrange them face up in this order: General Instructions, Question Sheets, Answer Sheets, Worksheets. Sort by page number.
- The supervisors will tell you when you can leave. Don't take anything from the room with you, including the calculator. We appreciate your collaboration.

Specific instructions

Throughout the exam, always use the values of physical constants indicated in the general instructions, unless otherwise noted. When performing numerical calculations, always indicate the units of the used quantities.

Physical Constants

Reference values for selected physical constants.

Constant	Notation	Value	Units
Speed of light in vacuum	c	2.99792458×10^8	$m \cdot s^{-1}$
Planck constant	h	$4.135667696 \dots \times 10^{-15}$	$eV \cdot s$
Reduced Planck constant	$\hbar = h/2\pi$	$6.582119569 \dots \times 10^{-16}$	$eV \cdot s$
Avogadro number	N_A	$6.02214076 \times 10^{23}$	mol^{-1}
Boltzmann constant	k_B	$8.617333262 \times 10^{-5}$	$eV \cdot K^{-1}$
Ideal gas constant	R	8.31446261815324	$kg \cdot m^2 \cdot s^{-2} \cdot mol^{-1} \cdot K^{-1}$
Elementary charge	e	$1.602176634 \times 10^{-19}$	$A \cdot s$
Universal gravitational constant	G	$6.67430(15) \times 10^{-11}$	$m^3 \cdot kg^{-1} \cdot s^{-2}$
Stefan Boltzmann constant	σ	$5.670374419 \times 10^{-8}$	$kg \cdot s^{-3} \cdot K^{-4}$
Vacuum permeability	μ_0	$1.25663706127(20) \times 10^{-6}$	$kg \cdot m \cdot A^{-2} \cdot s^{-2}$
Vacuum permittivity	ϵ_0	$8.8541878188(14) \times 10^{-12}$	$A^2 \cdot s^4 \cdot kg^{-1} \cdot m^{-3}$
Mass of the electron	m_e	$5.1099895069(16) \times 10^{-5}$	eV/c^2
Mass of the proton	m_p	$9.3827208943(29) \times 10^{-8}$	eV/c^2
Atomic mass units	amu	$9.3149410372(29) \times 10^{-8}$	eV/c^2