Harvard Undergraduate Science Olympiad 2026
Open Round
Physics Syllabus: 9th-10th Grade

Reference Material: You will be provided with a list of fundamental constants that may be useful during the exam. Any formulas that you are not expected to know will be given in relevant questions.

Potential Topics Covered on the Exam:
Please note that not necessarily every topic on this list will be on the exam, don't get overwhelmed! The syllabus is meant to be exhaustive of all *potential* topics that could be on the exam. A great place to start is with making sure you're comfortable with the ICSE curriculum for 9th-10th grade. It will be a difficult exam, but remember you don't need to (nor do we expect you) get a 100%! Just do your best and show us all that you've learned! Good luck and happy studying!

The open exam round will broadly cover two main subjects, Mechanics, Electromagnetism, and Thermodynamics. More specific topics will be listed below. It is expected that fundamental knowledge (such as concepts and formulas) from these topics will be known, and will not be provided in the exam. Formulas and constants that will be provided in the exam are in the reference sheet at the back of this syllabus.

- Mechanics
    - Kinematics, Dynamics, Vector and Scalar Quantities, Conservation Laws (Energy, Momentum, Angular Momentum), Circular Motion, Rotation, Simple Harmonic Motion, and Gravity
- Electromagnetism
    - Circuits (Resistors, Capacitors, Batteries)
- Thermodynamics

    - The Three Laws of Thermodynamics, Heat Transfer, Heat Capacity, Specific Heat, Phases of Matter and Phase Transitions, Ideal Gas
- Acoustics
    - Sound, Loudness, Pitch and Frequency, Longitudinal Waves, Reflection of Waves

Preparation for Exam: The following textbooks are often considered gold standards for physics education. All of the knowledge expected of students will be found in these textbooks.

1.
Problems and Solutions in Introductory Mechanics by David Morin

This book focuses on Newtonian mechanics, which will only make up a part of the exam. Despite this, this book is very good for students who want to develop their physical intuition. A wide variety of carefully crafted problems and solutions will challenge students to think deeper about the physics of certain scenarios. This will help students with their problem solving skills that will be essential for this exam.

2.
Fundamentals of Physics 10e by David Halliday, Robert Resnick, and Jearl Walker

This book covers all of the topics that will potentially be covered in the exam. Students will be expected to have read chapters 2-11, 13, 16, 17, 18, 21-28, and 34. There are plenty of good example questions that will help make confusing concepts much easier to understand.

Sample Questions: More questions of a comparable difficulty can be found on the website for the United States Physics Bowl (https://www.aapt.org/Programs/PhysicsBowl/printexams.cfm) The questions in the beginning of the exam will be rather simple, and can be solved in a matter of seconds.

Examples.

1. What is the equation for the moment of inertia of a thin stick with total length L and mass M about its end?
    a. ML^2
    b. $\frac{ML^2}{2}$
    c. $\frac{ML^2}{3}$
    d. $\frac{ML^2}{4}$
    e. $\frac{ML^2}{6}$

2. What is the speed of light through a transparent substance with a refractive index of 3.0?

a. 9.0×10^8 m/s
b. 3.0×10^8 m/s
c. 1.0×10^8 m/s
d. 9.0×10^7 m/s
e. 1.0×10^7 m/s

They will then progress in difficulty to a level where it will take more time.

1. 7 moles of an ideal gas undergoes an expansion from 16 L to 20 L at a constant temperature of 65˚C. How much work is done by the gas during this expansion?
    a. 200 J
    b. 440 J
    c. 4,400 J
    d. 11,000 J
    e. 25,000 J

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Open Round
Physics Reference Sheet

Important Constant Values

Name	Symbol	Value	Units
Universal Gravity Constant	G	6.674×10^{-11}	$\frac{m^3}{kg\,s^2}$
Speed of Light	c	2.998×10^{8}	$\frac{m}{s}$
Mass of Proton	m_p	1.673×10^{-27}	kg
Mass of Neutron	m_n	1.675×10^{-27}	kg
Mass of Electron	m_e	9.109×10^{-31}	kg
Universal Gas Constant	R	8.315	$\frac{J}{mol\,K}$
Permittivity of Free Space	ϵ_0	8.854×10^{-12}	$\frac{A^2 s^4}{m^3 kg}$
Permeability of Free Space	μ_0	$4\pi \times 10^{-7}$	$\frac{m\,kg}{A^2 s^2}$
Avogadro's Number	N_A	6.022×10^{23}	$\frac{1}{mol}$
Elementary Charge	e	1.602×10^{-19}	C

Speed of Sound in Dry Air (STP)	v_s	343	$\frac{m}{s}$
Planck's Constant	h	6.626×10^{-34}	$J\,s$

Important Formulas

$v_f = v_i + at$	$x_f = x_i + v_i t + \frac{at^2}{2}$	$v_f^{\,2} = v_i^{\,2} + 2a(x_f - x_i)$
$F = ma$	$a = \frac{v^2}{r}$	$p = mv$
$F_f = \mu n$	$F_k = -kx$	$W = Fd$
$KE = \frac{mv^2}{2}$	$U_g = mgh$	$U_k = \frac{kx^2}{2}$
$P = \frac{W}{t}$	$p_f = p_i + Ft$	$\tau = I\alpha$
$I_{ring} = mr^2$	$I_{disk} = \frac{mr^2}{2}$	$I_{stick,\,center} = \frac{ml^2}{12}$
$I_d = I_0 + md^2$	$T = 2\pi\sqrt{\frac{L}{g}}$	$T = 2\pi\sqrt{\frac{m}{k}}$
$f = \frac{\omega}{2\pi} = \frac{1}{T}$	$L = I\omega$	$L_f = L_i + \tau t$
$F = \frac{q_2 q_2}{4\pi\varepsilon_0 r^2}$	$F = qE$	$V = -Ed$
$R = \frac{\rho L}{A}$	$R_{eq,\,series} = \Sigma R$	$\frac{1}{R_{eq,\,parallel}} = \Sigma\frac{1}{R}$
$V = IR$	$I = \frac{q}{t}$	$E = hf$
$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$	$f = \frac{r}{2}$	$v = \lambda f$