# CAP High School/CEGEP Prize Exam

## April 10, 2022

### Student Information Sheet

The following information will be used to inform students and schools of the exam results, to determine eligibility for some subsequent competitions and for statistical purposes. Only the marking code, to be assigned by the local examination committee, will be used to identify papers for marking.

| Marking Code: |
|---|

This box must be left empty.

### PLEASE PRINT CLEARLY IN BLOCK LETTERS

| Student First Name | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| Student Last Name | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Please write all information in English.

School: _____     Grade: _____

Account number: _____

Gender: _____     Citizenship: _____

*By signing this page I agree that, if my score on this Exam is in the top 20 nationally or in the top 6 in my province, my name, my school's name, and my ranking can be published.*

Student's signature: _____

## 2022 Canadian Association of Physicists Highschool/Cegep Prize Exam

This is a three-hour exam. National ranking and prizes will be based on students' performance on sections A and B of the exam. Performance on questions in section A will be used to determine whose written work in section B will be marked for prize consideration by the CAP Exam National Committee. Section A consists of 25 multiple-choice questions. The questions in section B span a range of difficulty, and may require graphing and/or measurement on the graph. Be careful to gather as many of the easier marks as possible before venturing into more difficult territory. When you are unable to solve any part of a question, you may assume a likely answer to that part and attempt the rest of the question anyway.

Non-programmable calculators may be used. Answer the multiple-choice questions **on the answer sheet** provided. Most importantly: write your solutions to the three long problems on **three separate sheets** as they will be marked by people in different parts of Canada. Good luck.

**Notice**: Full marks will be given to students who provide full correct solutions to problems in Section B. Partial marks will be given for partial solutions. There are no penalties for incorrect answers. The questions are not of equal difficulty. Remember that we are challenging the best physics students in Canada; it is possible that even

This Exam is meant to be challenging!

### Data

Speed of light $c = 3.00 \times 10^8$ m/s
Speed of sound in air $= 343$ m/s
Gravitational constant $G = 6.67 \times 10^{-11}$ N·m$^2$/kg$^2$
Acceleration due to gravity $g = 9.81$ m/s$^2$
Standard atmospheric pressure $P_0 = 1.01 \times 10^5$Pa
Density of fresh water $\rho = 1.00 \times 10^3$ kg/m$^3$
Density of ice $\rho_i = 916$ kg/m$^3$
Specific heat of water $C_w = 4186$ J/(kg·K)
Specific heat of ice $C_i = 2050$ J/(kg·K)
Latent heat of water $L_w = 2260$ kJ/kg
Latent heat of ice $L_i = 334$ kJ/kg
Fundamental charge $e = 1.60 \times 10^{-19}$ C
Mass of an electron $m_e = 9.11 \times 10^{-31}$ kg
Mass of a proton $m_p = 1.67 \times 10^{-27}$ kg
Planck's constant $h = 6.63 \times 10^{-34}$ J·s

1 eV $\approx 1.602 \times 10^{-19}$ J
Electrostatic constant $k = 1/4\pi\epsilon_0 = 8.99 \times 10^9 N \cdot m^2/C^2$
Permittivity of free space $\epsilon_0 = 8.854 \times 10^{-12}$ C$^2$/N·m$^2$
Boltzmann's constant $k_B = 1.38 \times 10^{-23}$ J/K
Stefan–Boltzmann constant $\sigma = 5.67 \times 10^{-8}$ W/m$^2$· K$^4$
Astronomical Unit (approximate distance from the Sun to the Earth) 1 AU $= 1.49598 \times 10^{11}$ m
Radius of the Earth $R_E = 6.371 \times 10^6$ m
Radius of the Sun $R_S = 6.96 \times 10^8$ m
Mass of the Earth $5.97 \times 10^{24}$ kg
Mass of the Sun $1.99 \times 10^{30}$ kg
H$_2$ Molar mass 2.016 g/mol
O$_2$ Molar mass 31.998 g/mol
N$_2$ Molar mass 28.013 g/mol

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