CHMMC CONVENTIONS

1 Test-Taking Conventions

The following test-taking and answer conventions are adapted from the ARML[1] and HMMT[2] mathematical conventions.

1.1 Team and Individual Round

The answers to the problems on the Team and Individual Rounds are numerical values. The short answer responses to the problems of the Team and Individual Rounds should be exact and *reasonably simplified*. If the numerical value of a student's submission to a problem does not match the corresponding answer to the problem on the answer key, then the submission will be marked incorrect. Even if the numerical value of a submission matches that of the answer key, the submission may still be marked incorrect. To ensure that you earn credit for correct answers, please follow the guidelines below.

1. Carry out reasonable calculations. This includes any answer format involving integers less than 10^5. For instance, write 2^{15} as 32768 and write $\frac{1}{5}\cdot\frac{1}{5}\cdot\frac{1}{881}\cdot\sqrt{9999}=\frac{3\sqrt{1111}}{22025}$ as $\frac{3\sqrt{1111}}{22025}$. Other easy-to-compute arithmetic expressions, e.g. $365\cdot1001$, should also be carried out. Unreasonable calculations include powers and factorials greater than 10^5 (e.g. $7^{11}, 12!$), irrational expressions with logarithms (e.g. $2\ln 3-5\ln 2$), expressions involving non-algebraic constants (such as e or π), or irrational expressions with trig/inverse trig functions that cannot be "simply" expressed in terms of radicals (e.g. $\sin 4^\circ$).
    - Generally speaking, you are allowed to use exponents, factorials, trigonometric and inverse trigonometric functions, logarithmic functions, the constants π and e, and binomial coefficients to express your answers in reasonably simplified form. The above list is not exhaustive. However, you are never allowed to write your answers in non-closed form, i.e. using $\sum$ or $\prod$ notation, as an infinite sum or product, or as some step of a recursive relation.
    - Expressions involving logarithms and trigonometric functions etc. must also be simplified to a reasonable extent. For instance, write $\sin(\frac{5}{2}\cdot\arcsin(\frac{1}{2}))$ as $\frac{\sqrt{6}+\sqrt{2}}{4}$, and write $\frac{1}{\log_{10}e^3-\log_{10}e}\cdot\frac{1}{\ln 2}$ as $\frac{1}{2}\log_2 10$.
    - Assuming a correct answer, it should be *unambiguous* whether certain calculations need to be carried out to simplify an answer or not.
2. Any answers that are expressed in terms of a fraction, e.g. $\frac{3}{5}$, must have "relatively prime" numerators and denominators. For instance, write $\frac{21}{35}$ as $\frac{3}{5}$, write $\frac{3^{40}-3^{15}}{45}$ as $\frac{3^{38}-3^{13}}{5}$, and write $\frac{12\sqrt{15}-20\sqrt{7}}{30}$ as $\frac{6\sqrt{15}-10\sqrt{7}}{15}$.
    - Answers that are rational numbers should be expressed in terms of a fraction instead of a decimal or a mixed number.
3. "Reduce" radicals as much as possible. This includes eliminating the usage of radicals when applicable and moving all powers outside of radicals: write $\sqrt[4]{2401}$ as 7, write $2\sqrt{45}$ as $6\sqrt{5}$, and write $\sqrt[3]{81}$ as $3\sqrt[3]{3}$. Denominators must be rationalized: write $\frac{10}{3+i}$ as $3-i$, and write $\frac{6}{\sqrt[3]{5}}$ as $\frac{6\sqrt[3]{25}}{5}$.
4. When a problem asks for an ordered pair (a,b) (or an ordered triple, etc.), an answer must be given in precisely that form, including the parentheses and the comma.

[1] https://mathleague.org/conventions.pdf
[2] https://hmmt-prod.s3.amazonaws.com/static/acceptable_answers.pdf

5. When a problem asks to list multiple items, each item should be listed with a comma separating distinct items for clarity. For example, if the problem is "find all prime numbers less than 10," the contestant should write "$2,3,5,7$".

Good examples of reasonably simplified answers can be found on the solution keys to the Team and Individual Rounds at `https://www.chmmc.org/problems` (note that the answers to the Team and Individual rounds in 2020-2021 and 2021-2022 were integers due to an online competition). Otherwise, the following table gives some more examples of unsimplified answer formats along with their appropriate simplifications (remark that the last 3 simplifications are subtler than the others):

Unsimplified	**Simplified**
$42 \cdot 10000$	420000
$-\frac{12}{10}$	$-\frac{6}{5}, \frac{-6}{5}$
$\frac{15}{\sqrt{10}}$	$\frac{3\sqrt{10}}{2}$
$\frac{1+i}{2-i}$	$\frac{1+3i}{5}$
$\binom{12}{4}$	495
$\frac{6\ln 8 - 12\ln 4}{3}$	$-2\ln 2$
$\sin(20^\circ)+\sin(40^\circ)$	$\sin(80^\circ)$
$\sqrt[4]{25(101\cdot 102\cdot 103\cdot 104+1)}$	$5\sqrt{2101}$

Important: whenever a problem calls for an answer in a specific format, e.g. as a prime factorization or an infinite sum, the answer format called by that problem takes *precedent* over the above guidelines.

Answers that are not reasonably simplified will be marked as incorrect. The decisions of the CHMMC coordinators and graders are **final**.

1.2 Power Round

The following general conventions are in place for problems on the Power Round.

1. Every **Problem** is labeled with a point value. For multi-part problems, each part is labeled with a point value, and the multi-part problem itself is labeled with the sum of the point values of its parts. The point value indicates the general difficulty of each problem/part.
2. A problem worded with "compute" will always call for an **exact numerical answer or algebraic expression**. In this case, credit will be awarded only based on providing a correct answer. Answers are still expected to be *reasonably simplified* as in the Team and Individual Rounds.
3. Problems not worded with "compute" will **require explanation or proof**, unless otherwise specified.
   - Explanations/proofs will be graded on *correctness* and not *readability*. However, unreadable submissions/parts of submissions will be assumed incorrect and lose you credit, so we encourage you to write proofs clearly and carefully!
   - For problems that call for a final answer (and an explanation), no credit will be earned for a submission providing a final answer without an explanation.
4. In your solution to a given problem or part, you may cite the results of **earlier** problems, parts, theorems, etc. (but not **later** ones), without additional justification, even if you have not solved them. You may also cite any "standard" results used in AMC/AIME/USA(J)MO/IMO as long as they do not completely trivialize the problem.

2 Common Terminology

You will find the following common competition math terminology on the Power, Team, and Individual rounds. We expect you to be familiar with this.

2.1 Sets and Set Theory

1. The natural numbers (positive integers), integers, rationals, reals, and complex numbers will be denoted by $\mathbb{N}, \mathbb{Z}, \mathbb{Q}, \mathbb{R}$, and $\mathbb{C}$, respectively.
2. For two sets S, T, the notations $S \cap T$ and $S \cup T$ mean the intersection and union of S and T, respectively. For a collection of sets $A_1, \ldots, A_n$ we may use notation such as $\bigcup_{i=1}^{n} A_i$ or $\bigcap_{i=1}^{n} A_i$, which denote the union and intersection of all of $A_1, \ldots, A_n$, respectively.
3. We say $S \subset T$ or $S \subseteq T$ whenever S is a subset of T. Note: $S \subset T$ does not necessarily mean S is a *proper* subset of T, i.e. it does not exclude the case $S = T$.
4. The Cartesian product of two sets S and T will be denoted $S \times T$, and the n-fold Cartesian product of S will be denoted S^n.
5. Given two sets S and T, $f : S \to T$ indicates a function f with domain S and codomain T.

2.2 Algebra

1. A lattice point in $\mathbb{R}^n$ is a point $(a_1, \ldots, a_n)$ such that all of its coordinates are integers (in most circumstances, the terminology will be used for ordered pairs or ordered triples of numbers).
2. For any real value x, the *floor* and *ceiling* of x shall be denoted $\lfloor x \rfloor$ and $\lceil x \rceil$, respectively.
3. Logs are base 10 unless otherwise indicated by a subscript (for example, $\log_4 64 = 3$). The domain of a log function is a set of positive numbers. The base e natural logarithm shall be written as "ln."
4. If complex numbers are used in a problem, i denotes $\sqrt{-1}$. For any complex number z, $\mathrm{Re}(z)$ and $\mathrm{Im}(z)$ denotes the *real* and *complex* part of z, respectively. For instance, if $z = 3 + 7i$, then $\mathrm{Re}(z) = 3, \mathrm{Im}(z) = 7$.
5. The expressions $\sin^{-1}(x)$, $\cos^{-1}(x)$, and $\tan^{-1}(x)$ refer to the principal values of these inverse trigonometric functions. The ranges are $-\frac{\pi}{2} \leq \sin^{-1}(x) \leq \frac{\pi}{2}, 0 \leq \cos^{-1}(x) \leq \pi, -\frac{\pi}{2} < \tan^{-1}(x) < \frac{\pi}{2}$.
6. Intervals over the real numbers are written as a pair of numbers. Round brackets indicate that the endpoint is excluded, while square brackets indicate that the endpoint is included. For example, the interval $(2, 3]$ denotes the set of all reals x such that $2 < x \leq 3$.
7. Given a set $\{a_1, \ldots, a_n\}$ of real numbers, $\max\{a_1, \ldots, a_n\}$ denotes the maximum value in the set; $\min\{a_1, \ldots, a_n\}$ denotes the minimum value in the set.
8. All polynomials are single-variable unless otherwise noted. A *monic* polynomial is a single-variable polynomial with leading coefficient 1, i.e. $x^3 + 3$ is monic but $2x^4 + 10x + 1$ is not.

2.3 Combinatorics

- Symbols for combinatorics: $\binom{n}{r}$ denotes the number of ways to choose r things out of n things.

2.4 Geometry

1. If a polygon is named $ABCDEF$, it is understood that the vertices A, B, C, D, E, F occur in this order around the polygon, whether clockwise or counterclockwise. Unless otherwise specified, references to polygons, including triangles, should be understood to mean simple, non-degenerate, ones. The square brackets notation $[ABCDEF]$ indicates the positive area of the polygon.

2. The overline notation $\overline{AB}$ refers to the line through points A and B. The notation AB refers to the unsigned length of the segment with endpoints A and B.

3. The notation $\angle ABC$ refers to either the angle or the measure of the angle defined by $\overline{AB}$ and $\overline{BC}$. Angle measures always refer to the non-reflex angle, and are never directed.

2.5 Number Theory

1. The word "prime" refers to positive numbers only. Of course, 1 is not a prime.

2. Divisors of an integer refer to positive numbers only. Proper divisors of an integer refer to divisors that are less than that integer.

3. Integers in other bases shall be indicated by a subscript, i.e. $321_4 = 3 \cdot 4^2 + 2 \cdot 4^1 + 1 \cdot 4^0 = 57$.

4. The underline notation $\underline{a_n a_{n-1} \ldots a_0 . b_1 \ldots b_m}$ refers to the $m+n$-digit decimal number $10^n a_n + \cdots + 10a_1 + a_0 + 10^{-1} b_1 + \cdots + 10^{-m} b_m$. Sometimes the underline notation will be omitted if the context is clear.

5. An overline notation will be used to indicate a repeating decimal, i.e. $1.4\overline{32} = 1.4323232\ldots$.