Math and Physics Guidelines in AstroChallenge.

In order to clarify concerns from several about what exactly is "fair game" for AstroChallenge participants, we have decided to give some general guidelines about this issue. While these guidelines are **not meant to be exhaustive**, they should give a good overview about the mathematical & physical concepts that are involved. Note that **these guidelines are subject to change**, and not all topics within these limits will be tested every year.

If you would like a more detailed introduction into the conceptual and mathematical aspects of astronomy, you may want to refer to www.astronomynotes.com for a comprehensive text. Should you need further clarification about these guidelines, please contact us at astrochallenge@gmail.com

Juniors

- Participants should be comfortable with algebra: e.g. factorization, changing the subject of an equation, solving simultaneous equations and quadratics etc.

- Participants should be familiar with basic functions such as exponentials, logarithms and trigonometric functions. They should also be able to tackle problems involving angles and basic geometry. They should also be able to apply the **small angle approximations and first-order binomial expansion** (given in the Formula Booklet) where appropriate.

- Participants should also be cognizant of the concept of significant figures and standard form ($x \times 10^n$).

  Note: unless otherwise specified, numerical answers in AstroChallenge (for both Juniors and Seniors) may be left to 3 significant figures, or 2 decimal places in the case of angles.

In addition to the topics included in the O level Physics and Math syllabi, participants should also:

- Understand the concept of **gravitation** and related quantities such as gravitational acceleration and gravitational potential. Participants should know how to use and manipulate these formulae to solve for other quantities.
  Appropriate formulae have been included in the Formula Booklet for reference.

- Have a good understanding of **circular motion** (e.g. that a force is required to keep a body in circular motion) and apply the relevant formulae to solve questions in an astronomy context. Hence, participants should be comfortable working with variables such as velocity, centripetal force and centripetal acceleration.
  Appropriate formulae have been included in the Formula Booklet for reference.

- Be familiar with **basic concepts in orbital mechanics**, such as the semi-major axis, eccentricity, orbital period and Kepler's laws of motion. Participants should also expect to apply concepts from other areas like gravitation and circular motion to solve such questions.

- Appreciate the idea of **electromagnetic radiation** in its many forms. They should be comfortable with the concept of a **black body** and mathematically describe how a black body emits radiation through **Wien's displacement Law** and the **Stefan-Boltzmann Law** (both of which ultimately come from Planck's Law). They should also understand **the**

Doppler Effect and how it is mathematically described through the **redshift formulae**. Said formulae have been included in the Formula Booklet for reference.

Note: The derivation of Wien's displacement law and the Stefan-Boltzmann Law is not tested

- Know the formulae and variables used in **practical astronomy**, including but not limited to angular measure, field of view, f-ratio, focal length, aperture size, magnification and so on. They should also understand the significance and limitations of the **Rayleigh criterion**.

  Note: Only the formula for the Rayleigh criterion will be provided.

- Participants should be able to appreciate and apply the key formulae and concepts that are used in **observational astronomy**, such as the magnitude system, parallax, distance modulus, inverse square law etc. Participants should also know how to use and apply **empirical relationships** as given in the Formula Booklet and specific questions.
  Appropriate formulae have been included in the Formula Booklet for reference.

<u>Seniors</u>

Seniors are expected to have a deeper understanding of the topics in the Junior category. In addition to the above, they should:

- Be able to handle **calculus** problems involving derivatives, integrals and simple differential equations. They are not expected to evaluate partial derivatives, double integrals, triple integrals, line integrals and surface integrals.

- Have a basic understanding of **special relativity** and **general relativity**, such as its postulates, implications and how they apply in an astronomical context. Participants will not be tested on the derivation of formulae in special relativity (e.g. the Lorentz Transformation). Instead, the relevant formulae will be provided in the Formula Booklet. Participants will not be tested on formulae used in general relativity, but are expected to appreciate the ideas, concepts and implications of the equations.

- Be aware of the concept of **angular momentum**. Participants are not expected to compute the Moment of Inertia of an object. If tested, participants are only expected to use angular momentum in problems involving orbital mechanics and related applications.

- Have a basic understanding of **vectors in 3D**. Emphasis will be placed on determining magnitudes and directions of vectors, as well as their interpretation. Participants should be able to manipulate vector quantities in the context of astronomy, especially through the techniques of vector addition and vector resolution. If tested, participants are only expected to be able to evaluate a given dot or cross product.

- Be able to comprehend **given results/equations from spherical geometry** in the context of the celestial sphere. They should be able to manipulate a given equation/result, and appreciate its implications. If tested, appropriate guiding explanations/context will accompany any given result/equation.