Mathematical Skills Inventory for IPhO

Preamble:

The International Physics Olympiad (IPhO) is the world's premier competition for high school physics students (or students just out of high school). The Philippines has been participating in the IPhO since 1993. The IPhO Syllabus gives an idea of the physics coverage of the IPhO. However the description of the mathematics requirements of the IPhO is vague. The only requirement is that is should be possible to solve IPhO problems without using complex variables, complicated differential equations and <u>extensive</u> use of calculus. However students are not penalized for using advance mathematical techniques and extensive is a subjective term. On rare occasions, very simple mathematical techniques are required. This document is an attempt to list the mathematical skills that I have seen necessary for solving past IPhO problems. This is an evolving document. Suggestions are welcome.

Starting 1998, prospective Philippine participants to the IPhO will be expected to have learned many of the following mathematical skills evens before the start of the summer training program.

Approximation, Estimation, and Graph Interpretation

 routine use of order of magnitude estimates before solving long problems
 use of dimensional analysis to derive non-trivial relations and check results
 recognition of equations which cannot be solved exactly
 ability to get numerical solutions of transcendental equations using techniques such as Newto's method and bisection method
 ability to make small variable approximations using the binomial theorem, angle addition formula, and Taylor series
 distinguish 0th, 1st, and 2nd order approximations
 approximation of derivatives
 approximation of integrals
 use of total and partial differentials to estimate propagated errors
 transformation of non-linear relations to linear form
 linear regression

-decompose, add, and subtract vector
-evaluate magnitudes of vectors
-obtain vectors normal to a given vector
-evaluate dot and cross products using a variety of methods
-manipulate tangent and normal vectors
-differentiate and integrate vectors
-recognize when vector operations are needed and when scalar operations are sufficient
-perform formal operations with vectors using commutative, associative, and distributive properties when appropriate
-use superposition of vectors in physical problems when appropriate

3. Calculus and differential equations -take derivatives of algebraic, logarithmic, exponential, trigonometric, and inverse trigonometric functions

-Take derivatives using sum rule, product rule, quotient rule, and chain rule

- -Perform implicit differentiation
- -Perform logarithmic differentiation

-Maximize or minimize continuous or discrete functions using methods of differential calculus and the properties of quadratic functions, trigonometric functions, and rational functions -Apply the notion of a derivative as a slope or as a rate of change when appropriate

-Approximate using differentials

-Solve related rates problems

-Exploit the fact that differentiation and integration are inverse operations

-integrate standard forms

-integrate using change of variables, integration by parts, and trigonometric substitution -distinguish definite integrals and indefinite integrals

-apply integration to evaluate position of center of mass, moment of inertia, electric fields, magnetic fields etc.

-set up integrals and differential equations by arguing in terms of infinitesimal changes in time, length, volume, or other physical quantities

-solve differential equations using separation of variables

-solve linear differential equations

- 4. Mastery of high school algebra, geometry, and trigonometry
- 5. Summation of series: geometric, arithmetic, differentiation trick

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