Singapore Junior Physics Olympiad

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1 Greetings

Hi juniors, I am Tingkai. When writing this, I am a J2 in Hwa Chong Institution College Section, from class 18S7B.

I will try my best to make these notes simple and understandable. Given that I went through the process of learning myself, going from not knowing to knowing, I hope I know what you don't know.

If you have any feedback, feel free to email me at xuetingkai2001@gmail.com

2 My Learning Approach

Definitely, some memory work is needed, but in general I do not recommend memorizing. This is very cliché, everyone is going to say this, but I prefer understanding the concept instead of memorizing. For formulas, I feel it is better to get used to it by using it more often. A lot of times, I can't remember the formula and I have to derive it on the spot.

According to my experience, memorizing may remove the meaning behind the formula. After all, our memory is not perfect and it can fail us.

3 Qualitative

I like to think of it this way. Laws, theories and principles are the reasons that guide our thinking. From a certain cause/ initial conditions, due to a certain law/theory/principle, I know a certain outcome/effect will occur.

Sometimes, it is just logic and common sense. I think we need to know these few techniques.

3.1 By Symmetry

This is when we get a feel that two things have certain similar characteristics. How do we know that the centre of mass of a circle and a square is in the middle? This is an important concept that we sometimes just take for granted/trivial. It is hard to explain without exact questions but do look out for cases where symmetry occurs.

3.2 By Scaling

A cube has a mass of 1kg. Given if its dimensions are doubled and the material is the same, what is the mass of the new cube? We would guess 8kg, as a cube has a length, width and height. If all are doubled, it will be $222 = 8$ times of the original. Again, this is trivial, but it is a useful technique.

3.3 By Extension

I'm not sure if this is what you call it. But sometimes, you may have to imagine something that does not exist, which can then help you simplify the problem to something more solvable. This is similar to when you draw on extra line in a geometry problem, so you can then exploit certain properties.

That's all that come to my mind. Honestly, there isn't really a hard and fast rule on what tricks we need to know. Sometimes we just need to more sharp.

4 Quantitative

We will encounter a lot of formula in Physics. They show the relationship between various quantities. I believe we should not just think of them as mere symbols, but instead understand the physical significance of the quantities.

I like to think of Mathematics as a tool in Physics that helps us solve equations and get the answer that we want. Along the way, you may come across calculus, vectors etc.

In short: **Lay out the equations you know and solve it.**

4.1 Dimensional Analysis

This is a simple yet critical concept in Physics — the units in a formula/equation must work out. Here are a few rules:

1. When adding two quantities, the two quantities must have the same units. What does 1 kg + 1 m even mean.....?

2. When multiplying/dividing, the units also sort of multiply/divide. The units for distance is metres(m). The units for time is second(s). Therefore, the change in distance per unit time, speed, has units $m\,s^{-1}$

When laying out equations, always be aware: do the units work out. In fact, this is even a method for finding a possible equation/formula for a quantity. Basically, the two sides of the equation must have the same units.

4.2 Calculus and Vector

I don't think the exact notations and equations are required, but I do believe a qualitative understanding of how it works and what it means is necessary and helpful.

4.3 Approximations

In Physics and Engineering, we will come across various approximations. Sometimes people even write: $\pi = 3$. Of course, the answer we get is not exactly the actual answer, but sometimes it is close enough and it greatly simplifies the process of calculation. Here are a few examples:

$$sin\theta \approx tan\theta \approx \theta \quad cos\theta \approx 1 - \frac{\theta^2}{2}$$

In SJPO, the approximations are usually given in the question.