Greetings,

Well, 2020 has been quite an interesting year. It has proven to be a major challenge for teaching and learning; and definitely wasn't the best year for hosting academic contests. I was pleased that we were able to have a virtual academic at-home experience for our scholars, but I do hope we can be back to regular academic contests in 2021.

I am not planning any major changes in the physics section for this upcoming year. I think the level of the physics questions has been good and I really like the arrangement of having specific topics assigned to specific question numbers. We didn't get to observe what effect the addition of the two-line calculator has had; so, I will keep things about the same and we can collect data on that next spring. Once again, I appreciate any feedback that you may have about the physics questions or solutions. Below is the usual outline of physics topics. Note that P19-P20 (the wildcard questions) will remain focused on concepts encountered in the physics laboratory, and on the analysis of experimental data. Since physics is fundamentally an experimental science, I feel it is appropriate to keep it that way.

As before, the three directed reading questions will come first (P1-P3). The book for this year is "Seven Brief Lessons on Physics" by Carlo Rovelli. It's a very quick introduction to the concepts of quantum physics, relativity, particle physics, and cosmology. The book is noticeably short, but full of information. It is the kind of book that catches your attention and makes you want to go and learn more about these topics. For this year, the directed reading has seven chapters. I plan to break it down this way: questions for the Invitational A test will come from chapters 1-2, while questions for the Invitational B test will be from chapters 1-2-3. For the District test, I will choose questions from chapters 3-4. Questions for the Regional test will come from chapters 4-5-6, and questions for the State test will come from chapters 5-6-7. As always, I would encourage you to read the entire book regardless, but you need only review a few chapters prior to each contest.

Like previous years, the remainder of the test will focus of core physics concepts, with each question number on the tests being about the same topic. There will be a few conceptual questions, but most of the questions will be mathematical/numerical problems. At the Regional and State level, don't be surprised to see some problems involving Calculus, complex numbers, or vector notation. What is described below will give you the exact topics for each question and the chapters for those topics in three popular references.

Physics Questions P1 – P3 will always be from the reading material. This year that is from "Seven Brief Lessons on Physics" by Carlo Rovelli. Questions for the Invitational A test will come from chapters 1-2, while questions for the Invitational B test will be from chapters 1-2-3. For the District test, I will choose questions from chapters 3-4. Questions for the Regional test will come from chapters 4-5-6, and questions for the State test will come from chapters 5-6-7.

Physics Question P4 will always be from the field of **Astronomy**. I'll stick to major concepts such as star formation, evolution, and death; planetary systems (including our solar system); stellar processes; the structure of the universe (galaxies, clusters, superclusters, filaments and voids); and exotic objects such as quasars and pulsars. Recommended texts include "Foundations of Astronomy" by Seeds and Backman, "21st Century Astronomy" by Kay and Palen, and the OpenStax text "Astronomy".

Physics Question P5 will always be about **Measurement/Dimensional Analysis/Significant Figures/Order of Magnitude**. This is always the first thing in a Physics text and the foundation of experimentation and calculation. References: Chapter 1 in Giancoli (7th ed), Chapter 1 in Hewitt (12th ed), Chapter 1 in Serway and Vuille (10th ed).

Physics Question P6 will always be about **Uniformly Accelerated Motion**. Describing displacement, velocity, and acceleration in both one and two dimensions is always a staple of physics studies. This will include free-

fall and projectile motion. References: Chapters 2-3 in Giancoli (7th ed), Chapters 3, 10 in Hewitt (12th ed), Chapters 2-3 in Serway and Vuille (10th ed).

Physics Question P7 will always be about **Forces**. This is another major physics concept, with Newton's Laws at the forefront. Again, I'll have both one dimensional and two-dimensional problems, friction, and specific forces such as those due to springs or gravitation. References: Chapters 4-5 in Giancoli (7th ed), Chapters 2,4,5,9,10 in Hewitt (12th ed), Chapters 4,7 in Serway and Vuille (10th ed).

Physics Question P8 will always be about **Work/Energy/Power/Momentum**. Certainly, I cannot ignore two of the most important conservation laws in the field of physics: Conservation of Energy and Conservation of Momentum. This question may involve a single conservation law, be a combined energy-momentum problem, a power problem, or a work (force over a distance) problem. References: Chapters 6-7 in Giancoli (7th ed), Chapters 6-7 in Hewitt (12th ed), Chapters 5-6 in Serway and Vuille (10th ed).

Physics Question P9 will always be about **Circular and Rotational Motion/Equilibrium**. Simple problems include uniform circular motion, centripetal force, or balanced torques. This question could include rotational momentum or rotational energy. More advanced problems involve calculating rotational inertia, unbalanced torques, and rolling motion. References: Chapters 5, 8-9 in Giancoli (7th ed), Chapter 8 in Hewitt (12th ed), Chapters 7-8 in Serway and Vuille (10th ed).

Physics Question P10 will always be about **Waves/Sound/ Harmonic Motion**. This is a wonderfully broad subject, and not particularly difficult. I will include wave concepts such as superposition, waves on a string, standing waves, and wave motion. Sound topics include resonance, intensity, and the Doppler Effect. Simple harmonic motion includes systems such as masses on springs or the simple pendulum. More advanced questions may include damped or forced oscillations. References: Chapters 5, 11-12 in Giancoli (7th ed), Chapters 19-21 in Hewitt (12th ed), Chapters 13-14 in Serway and Vuille (10th ed).

Physics Question P11 will always be about **Fluid Statics and Dynamics/ Thermodynamics.** Fluid Statics includes Pascal's principle, pressure at depth, and density, while Fluid dynamics will usually involve Bernoulli's principle. Thermodynamics includes thermal expansion, thermodynamic laws, and heat transfer as well as more advanced concepts such as entropy, thermodynamics processes (adiabatic, isobaric, etc…) and heat engine cycles. References: Chapters 10, 13-15 in Giancoli (7th ed), Chapters 13-18 in Hewitt (12th ed), Chapters 9-12 in Serway and Vuille (10th ed).

Physics Question P12 will always be about **DC Circuits/Resistors/Capacitors**. Topics include Ohm's Law, and resistors (or capacitors) in series and parallel. More advanced concepts include Kirchhoff's Rules and RC circuits. References: Chapters 18-19 in Giancoli (7th ed), Chapter 23 in Hewitt (12th ed), Chapters 16-18 in Serway and Vuille (10th ed).

Physics Question P13 will always be about **Electric Fields and Forces/Electric Potential/Gauss' Law**. Fields are abstract, so they are naturally more challenging. This question could include one dimensional and two-dimensional Coulomb's Law, electric field, or electric potential problems as well as Gauss' Law at the advanced level. References: Chapters 16-17 in Giancoli (7th ed), Chapter 22 in Hewitt (12th ed), Chapters 15-16 in Serway and Vuille (10th ed).

Physics Question P14 will always be about **Magnetic Fields and Forces/Magnetic Materials/Ampere's Law**. Like Electric fields, magnetic field problems can get challenging, but who doesn't love the right-hand-rule. Topics include magnetic materials, charges and currents in magnetic fields, and magnetic fields due to long straight wires and in solenoids. Advanced topics include both Ampere's Law and the Biot-Savart Law. References: Chapter 20 in Giancoli (7th ed), Chapter 24 in Hewitt (12th ed), Chapter 19 in Serway and Vuille (10th ed).

Physics Question P15 will always be about **Faraday's Law/Induction/EM Oscillation and Waves/AC Circuits**. Dealing with changing magnetic fields, and oscillating currents and fields can be challenging. Faraday's Law is especially important here, as is Lenz' Law. Oscillating EM fields provide the basis for electromagnetic waves and our understanding of the EM spectrum, as well as light wave effects such as radiation pressure, polarization, and wave refraction. AC circuits, LC oscillations, RMS, RLC resonance, reactance and impedance will not show up prior to Regionals. References: Chapters 21-22 in Giancoli (7^{th} ed), Chapters 25-27 in Hewitt (12^{th} ed), Chapters 20-21 in Serway and Vuille (10^{th} ed).

Physics Question P16 will always be about **Geometric Optics/Wave Optics**. Lenses of all shapes, and curved and plane mirrors are fair game, as well as spherical refracting surfaces. There are many concepts to understand such as the difference between Real or Virtual images, knowing when images are Inverted or Upright, and calculating magnification. Advanced topics will include multiple element optical systems as well as wave optics concepts such as diffraction and interference. References: Chapters 23-24 in Giancoli (7^{th} ed), Chapters 28-29 in Hewitt (12^{th} ed), Chapters 22-24 in Serway and Vuille (10^{th} ed).

Physics Question P17 will always be about **Modern Physics/Quantum Physics**. There are a host of Modern topics including Spectroscopy, the Photoelectric effect, and Special relativity. At the advanced levels are Quantum questions involving the Heisenberg Uncertainty Principle, normalization, expectation values, the wave function, and the correspondence principle. References: Chapters 26-29 in Giancoli (7^{th} ed), Chapters 30-32, 35 in Hewitt (12^{th} ed), Chapters 26-28 in Serway and Vuille (10^{th} ed).

Physics Question P18 will always be about **Nuclear Physics/Particle Physics**. All competitors should know about radioactivity (alpha, beta, and gamma), decay chains, and half-lives as well as particle ideas such as the Standard Model, fundamental forces, conservation laws, and the properties of quarks and leptons. More advanced topics include binding energy, nuclear reactions (fission, fusion) and the interaction of radiation with matter (including living matter), as well as particle decay chains and rates, unification, spin, color, and early-universe cosmology. References: Chapters 30-32 in Giancoli (7^{th} ed), Chapters 33-34 in Hewitt (12^{th} ed), Chapters 29-30 in Serway and Vuille (10^{th} ed).

Physics Question P19 will always be a wildcard question from the topics traditionally covered in a Physics 1 course. That is from the topics covered in questions P5-P11. The wildcard questions will often focus on concepts encountered in the physics laboratory, and on the analysis of experimental data. References: Chapters 1-15 in Giancoli (7^{th} ed), Chapters 1-21 in Hewitt (12^{th} ed), Chapters 1-14 in Serway and Vuille (10^{th} ed).

Physics Question P20 will always be a wildcard question from the topics traditionally covered in a Physics 2 course. That is from the topics covered in questions P12-P18. The wildcard questions will often focus on concepts encountered in the physics laboratory, and on the analysis of experimental data. References: Chapters 16-32 in Giancoli (7^{th} ed), Chapters 22-35 in Hewitt (12^{th} ed), Chapters 15-30 in Serway and Vuille (10^{th} ed).

I hope this gives you an idea as to my thinking as I write these tests. Hopefully, this will help you build a study strategy that will maximize your success on the physics section. No test is perfect, but I will again do my best to ensure a fair and reasonable competition. Good luck to you, and let's all stay safe and healthy.

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