

Physics Packet

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1. **A law named for this scientist has a quantum analogue known as the Ward-Takahashi identity. This person made many contributions to abstract algebra and they name a type of ring which satisfies the ascending chain condition. This person's namesake identities characterize the degeneracy of a Lagrangian system. A theorem named for this scientist is often used in gauge theory and it relates (*) symmetries of an action functional with a system of differential equations.** For ten points, name this German physicist and mathematician who names a theorem that states that each symmetry of a system has a corresponding conservation law, her First theorem.

ANSWER: Emmy Noether

2. **Meissel investigated a variation of this problem that involved a Pythagorean triangle. Sundman found a solution to this problem which involved a power series with powers of the cube root of time. The figure-8 family is one set of solutions to this problem. A quantum analogue of this problem is the H two-plus ion, and a (*) restricted form of this problem has five equilibrium points, which are named for Lagrange.** This problem was shown by Poincare to not have a general solution that can be expressed in terms of algebraic expressions and integrals. For ten points, name this unsolved problem proposed by Newton which involves predicting the motion of a certain number of celestial objects that is often modeled by the sun, Earth, and Moon.

ANSWER: Three-body problem

3. **A value for the importance of centrifugal forces relative to viscous forces has a value equal to 1708 when described by this adjective. In 1950, Maxwell and Reynolds found that a quantity named for this adjective for a superconductor depends on the isotopic mass of the constituent elements. Calculating a quantity described by this adjective requires a (*) "fudge factor," which takes into account geometric effects. A tamper is used to decrease a value described by this adjective. A common decaffeination method uses carbon dioxide which is above a point described by this word, and beyond that point liquids and gasses become impossible to distinguish.** For ten points, name this word which is used to describe the angle of incidence that causes total internal reflection.

ANSWER: critical

4. **The Ising model limits the number of possible values of this quantity, whereas in the Heisenberg model there are an infinite possible number of values of this quantity. A crisis named after a proton and this quantity remains unsolved to this day. Interactions between this quantity and a particle's orbit contribute to (*) fine structure.** An experiment to distinguish particles by this quantity involved deflecting silver atoms through a magnetic field. That experiment was the Stern-Gerlach experiment. Particles with a half-integer value for this quantity are called fermions. For ten points, name this quantity which is the intrinsic angular momentum of a particle.

ANSWER: spin [prompt on "intrinsic angular momentum" before mention; do not accept or prompt on "angular momentum"]

5. **This quantity is in the denominator of the sine squared term in the Fraunhofer equation. A decrease in this quantity will result in Newton's rings getting smaller and this quantity is raised to**

the fifth power in Planck's Law. It was posited that this quantity existed for all moving particles and that it equaled (*) Planck's constant over momentum; that was stated by de Broglie. This quantity is multiplied by 1.22 and divided by D in a formula named for Rayleigh. This quantity equals velocity over frequency. For ten points, name this quantity which is increased during redshift symbolized λ .

ANSWER: **wavelength** [prompt on λ before mention]

6. Page and Wothers argued that this phenomenon could be used to measure time. Chien-Shiung Wu was the first to provide evidence of this phenomenon, although it had been theorized to exist earlier. The CHSH inequality can be used to prove a statement that says that no theory with local hidden variables can explain this phenomenon. That theory is named for (*) Bell, who also names states that experience the maximum amount of this phenomenon. The fact that this phenomenon appeared to break a law of physics was discussed in the EPR paradox. For ten points, name this phenomenon in which spatially separated particles have correlated quantum states, which Einstein deemed "spooky action at a distance".

ANSWER: quantum **entanglement**

7. Solutions to these equations are called dusts. Flat Minkowski space is an example of a trivial solution to these equations, and Schwarzschild developed the first non-trivial solution to these equations. Eight pi times big G all over c to the fourth power is a constant that appears in these equations. These equations were later edited to include a capital (*) λ term. That term was the cosmological constant and it was later considered to be its creator's "biggest blunders". For ten points, name this set of 10 equations often written in tensor notation, which is named for the physicist who developed general relativity.

ANSWER: **Einstein field** equations [or EFE]

8. A vacuum has a Ricci tensor equal to this value, and this is the momentum of the center of mass frame in special relativity. In 2013 scientists used a quantum gas of potassium atoms to surpass a value associated with this number. When potential and kinetic energies are equal, this is the value of the (*) Lagrangian. This value is equal to $\text{del} \cdot B$ by one of Maxwell's equations. A law named for this number states that thermal equilibrium is transitive, and this is the resistance of an ideal ammeter. If a particle were to have this value for its wavelength, then it would have infinite energy. For ten points, name this number which is the value of the mass of a photon.

ANSWER: **zero**

9. Interatomic distances in matter named for this man can be approximated by the equation d equals 2.9 times n squared times a_0 . This physicist's namesake constant can be expressed as the quantity \hbar over the Bohr radius squared, all over 2 times the electron rest mass. That constant and electron spin g -factor are the two most precisely measured physical constants. His constant appears in his namesake (*) formula where it is multiplied by the reciprocal of principal quantum numbers squared; that formula can be used to predict Lyman and Balmer series. For ten points, name this man whose formula validated the Bohr model and found the spectral lines of hydrogen.

ANSWER: Johannes **Rydberg**

10. **A quantity symbolized by this letter appears on the y-axis for Mohr's circle. DONUT was an experiment that set out to investigate interactions of particles named for this letter. A particle named for this letter is the only one of its kind that can decay into a hadron due to its large mass value. For a circuit with an inductor and (*) resistor, a quantity symbolized by this letter is equal to L over R . The reciprocal of the decay constant is equal to a quantity symbolized by this letter; that quantity is mean lifetime. In addition to shear stress, this letter represents a quantity equal to r cross F . For ten points, name this letter which is used to represent torque, and is also a mathematical constant equal to two pi.**

ANSWER: **tau**

11. **The Allais effect relates to these devices, and Kapitza names a type of this device. The first definition of a meter by Picard was related to one of these devices. One of these devices is attached to a car in a classic control theory question. The equation $3 \cos \theta - 1 + \cos \theta - 2$ equals (*) 2 relates to a form of this device. The square root of mgh over I appears in an equation relating to a "physical" one of these objects, and their "double" type is often associated with chaos. For ten points, name these devices whose "simple" type consists of a mass on a string, which are commonly used in grandfather clocks.**

ANSWER: **pendulums** [or **pendula**; prompt on simple harmonic oscillators]

12. **This person wrote their thesis on the interactions of fast neutrons with lead. Along with Livingood and Fairbrother, this man created a new isotope of iron, iron-59. He would later work with Livingood to create a different isotope which is today used to treat thyroid disease; that isotope is (*) iodine-131. He chaired the US Atomic Energy Commission for ten years and in 1944 this man developed the actinide concept. With Kennedy and Segrè, he discovered that plutonium-239 was fissionable. This physicist added 10 new elements to the periodic table. For ten points, name this man who was the first living person to have an element named after him, which was element 106.**

ANSWER: **Glenn Seaborg**

13. **After 2019, this quantity was redefined in terms of the fine-structure constant. The reciprocal of this constant appears in the definition of the H field. This number is the coefficient of current density in the differential form of Ampere's Law. The reciprocal of this constant appears in the formula for the Poynting vector. This constant is multiplied by current and number of loops to calculate a quantity for a (*) solenoid. Its value used to be exactly 4π times ten to the negative 7, and its units are Henrys per meter. This constant times epsilon-nought equals one over c squared. For ten points, name this fundamental constant often symbolized μ_0 , which measures the amount of resistance a vacuum has against the formation of a magnetic field.**

ANSWER: **permeability of free space** [or **magnetic permeability**; prompt on "mu-nought" before mention]

14. **Feynman described how this experiment differs from a similar situation involving a machine gun shooting bullets inaccurately. A simplified version of this experiment can be performed using a device named for Mach and Zehnder. Afshar demonstrated the principle of complementarity by using a version of this experiment, and (*) Wheeler discussed a variant known as the delayed choice experiment. The concept of negative probabilities is often demonstrated using this experiment. This**

experiment operates by producing fringes of light and dark called an interference pattern. For ten points name this experiment conducted by Thomas Young which demonstrated the wave nature of light using its namesake apparatus.

ANSWER: Young's **double-slit** experiment

15. A form of "acceleration" named for this man relates to how much energy is gained during the motion of charged particles in the presence of magnetic mirrors. This man thought that he had discovered element 94 which he called Hesperium but it was later shown to be a mixture of other elements. The probability of a quantum eigenstate is given by this man's Golden Rule and a (*) gas named after this person exerts pressure even at absolute zero. Element 100 is named for this man and he names a probability function along with Dirac. For ten points, name this man Italian-American who created Chicago Pile-1, the first man-made nuclear chain reaction, and worked on the Manhattan project.

ANSWER: Enrico **Fermi**

16. Hanna curves relate to these devices and the Nagaoka coefficient also describes these devices. Lundin's formula can calculate a certain quantity for one of these devices. A type of these devices called a choke blocks alternating current, and the impedance of these devices is directly related to the (*) frequency. The energy stored in one of these devices is equal to one half current squared times a namesake quantity. Two of these devices can be used to step up voltage in a transformer. These devices often contain a ferrite core and they, along with capacitors, appear in LC circuits. For ten points, name these circuit elements which are measured in Henry's and resist changes in current.

ANSWER: **inductors** [prompt on "solenoid"]

17. The violation of the conservation of this quantity caused Wheeler to speculate on the principle of mutability for all physical properties. This quantity is summed with strangeness, topness, bottomness, and charm in the definition of hypercharge. The Adler-Bell-Jackiw anomaly relates to the conservation of this quantity. The Georgi-Glashow theory predicts that protons can (*) decay which would result in the violation of conservation of this quantity, but that has not been observed. The proton and neutron have a value of 1 for this quantity, but leptons have a value of zero for this quantity because they are not made from quarks. For ten points, name this quantity which equals one third times the number of quarks minus the number of antiquarks.

ANSWER: **baryon** number

18. This quantity is multiplied by the number of moles of gas in an expression for the entropy of a monatomic ideal gas; that expression is called the Sackur-Tetrode equation. The most accurate measurement of this constant was found using a technique known as acoustic gas thermometry. This constant is divided by temperature in the (*) Eyring equation. That measured value was later used to redefine the Kelvin during the 2019 SI-unit redefinition. A famous equation for entropy features this constant being multiplied by the log of the number of microstates of a system; that equation is inscribed on the tombstone of its namesake. For ten points, name this constant named for an Austrian physicist which is commonly denoted kB.

ANSWER: **Boltzmann's** constant [prompt on kB before mention]

19. **This particle's wave function has a positive imaginary exponential in the solution of a first-order equation consisting of a beta matrix and three alpha matrices. A buffer-gas trap is a device built to accumulate these particles. As a graduate student, Chung Yao-Chao noticed behavior that indicated the existence of these particles before it was discovered using a device with (*) supersaturated water vapor. Radioactive tracers, such as fluorodeoxyglucose, are used in a medical technique named for these particles, and these charged particles are released in beta plus decay. For ten points, name these particles with the mass of an electron but the charge of a proton.**

ANSWER: **positron** [or antielectron]

20. **Brillouin names a form of this process that can be used to sense mechanical strain in optical fibers. A 785 nanometer laser is often used in one form of this effect, and another “magnetic” form of it uses circularly polarized photons to measure magnetic moments in ferromagnetic materials. An example of the inverse of this process occurs when CMB photons gain energy in an effect named for (*) Sunyaev and Zel’dovich. h or mc times one minus cosine theta gives the wavelength shift for a type of this process. The differential cross-section of a form of this process is given by the Klein-Nishina formula, and another form of this process explains why the sky is blue. For ten points, name this process where energy is exchanged in a collision of two particles, which has types named for Compton and Rayleigh.**

ANSWER: **scattering** [prompt on variants such as “Rayleigh scattering”]