Round 1

Regulation

(Tossup 1) This scientist generalized the action principle of classical mechanics to suggest that a particle's quantum amplitude is a sum over all possible trajectories. This developer of the path integral formulation won a Nobel Prize in physics in 1965 for his contributions to quantum electrodynamics. This scientist represented photons with wavy lines on his namesake diagrams, which are pictorial representations of the interactions between subatomic particles. For the point, name this American physicist known for his educational insights while working as a professor at CalTech.

ANSWER: Richard (Philips) **Feynman**

(Tossup 2) Hydroxy-lysine and hydroxy-proline are key amino acids in the structure of this protein. Vitamin C is a cofactor for the synthesis of this protein which has a glycine at every third residue, causing it to form three left handed helices that wind up into one tensile triple helix. Mutations in the production of this protein can cause Ehlers-Danlos syndrome, characterized by loose joints and stretchy skin. This protein is hydrolyzed to make gelatin. For the point, name this most common protein in the human body, found in connective tissue and cartilage.

ANSWER: **collagen**

(Tossup 3) Charged particles in a vacuum are intercepted by this scientist's namesake cup. An effect named for this scientist describes the polarization of light rays passing through a B-field. A law named for this scientist sets the electromotor force proportional to the negative change in magnetic flux. This scientist names a cage which screens electromagnetic radiation. This assistant to Sir Humphrey Davy names the SI unit of capacitance. For the point, name this English scientist whose study of electromagnetism led him to propose a namesake law of induction.

ANSWER: Michael **Faraday**

(Tossup 4) Manganese nodules can be found in this region and have been mined from here at great cost. Cold seeps in this region can create brine pools, while this region is famous for its "smokers," or hydrothermal vents. Harry Hess showed that this region's expansion is partially responsible for plate tectonics, creating alternating magnetic bands in the rock here. Basalt is the most common rock making up, for the point, what region of the Earth that lies underneath the Atlantic and Pacific?

ANSWER: **ocean floor** (accept **oceanic crust**; accept **seabed**; accept answers that indicate the **bottom of the ocean**)

(Tossup 5) On the twelfth space mission named for this constellation, Buzz Aldrin made a five and a half hour space walk tethered to the Agena Target Vehicle. The Eskimo and Medusa nebulas are found within this constellation, whose symbol resembles the Roman numeral for two. The two brightest stars in this constellation are collectively known as the Dioscuri and are associated with the myth of Castor and Pollux. For the point, name this constellation whose name is Latin for "twins."

ANSWER: **Gemini** (accept **Gemini 12**)

(Tossup 6) Eosinophils, basophils, and neutrophils are named for whether or not they retain one of these features named H&E. In one technique to create this feature, an iodine solution is added as a mordant after adding crystal violet to see if a bacteria has a thick or thin peptidoglycan [pep-tid-oh-GLY-can] wall; that technique was developed by Hans Christian Gram. Solvents can be used to fully remove these features, while bleach and hydrogen peroxide can remove their color. For the point, name these blemishes or dyes that are difficult to remove.

ANSWER: **stain**s (accept word forms like **stain**ing or **stain**ed; prompt on dye by asking "Used for what purpose?")

(Tossup 7) A conjecture named for "twins" of these mathematical objects posits that there are infinitely many of these constructs with a difference of two. The Mersenne type of these numbers are one less than a power of two. Much digital security relies on the fact that a given positive number has a unique factorization using only these numbers. The Sieve of Eratosthenes finds these numbers by progressively crossing out composite numbers. For the point, name this type of number which only has two factors of one and itself.

ANSWER: **prime** numbers (accept **prime**s)

(Tossup 8) Research by Arthur Ashkin, Gérard Mourou, and Donna Strickland on these devices won them the 2018 Nobel in Physics. In these devices, implementing Q-switching obtains higher peak power than continuous-wave operation. Pumping into the gain medium of these devices puts a majority of the electrons into higher energy states, a condition known as population inversion. For the point, name these devices that produce a collimated beam of coherent light, whose practical applications include barcode scanning.

ANSWER: **laser** (or **light amplification by stimulated emission of radiation**)

(Tossup 9) This organ's stellate cells can cause scarring upon activation, but typically store Vitamin A droplets. The sinusoids of this organ are lined with a special type of macrophage called Kupffer cells. This organ receives blood through the portal vein and helps with digestion by producing bile, which is stored in the gallblader beneath this organ. For the point, name this large internal organ damaged in cirrhosis, which can be a result of hepatitis or alcoholism.

ANSWER: the **liver**

(Tossup 10) Hilt's law relates the quality of this substance to the depth at which it is found. This substance's bituminous form can be processed into coke, while impurities may remain in the lignite form. This substance led to the naming of the Carboniferous period, as much of it was generated by the decomposition of forests during that period. Miners of this substance often contracted black lung from the inhalation of this substance's dust. For the point, name this solid fossil fuel often burned in early steam engines.

ANSWER: **coal**

(Tossup 11) One algorithm for doing this task in Python is named after Tim Peters, who noticed that he could be more efficient at this task by identifying existing runs. "MSD" and "LSD" are variants of the radix algorithm for this task. The "library" method for this task is related to its insertion type, where new data is placed between existing data. The swapping of neighboring values happens in the bubble variety of this task. For the point, name this task of arranging data, a common basic computer science problem.

ANSWER: **sort**ing

(Tossup 12) Ludwig Biermann's observations of the direction of comet tails was evidence of this phenomenon. This phenomenon ceases to be supersonic at a boundary called the termination shock but reaches as far as the heliopause. This phenomenon is largely the cause of "space weather" and it originates as particles accelerate enough to leave the corona. For the point, name this phenomenon, a release of particles from the sun that causes auroras when it reacts with Earth's ionosphere.

ANSWER: **solar wind**

(Tossup 13) When a copper rod is suspended in a solution of this element's nitrate, a blue solution of copper nitrate forms along with crystals of this element. A thin plate of this element over a copper substrate is the starting material for a daguerreotype [da-GARE-oh-type]. When Tollens reagent is added in presence of an aldehyde, a "mirror" of this element forms. This metal has the highest conductivity and forms the alloy electrum with gold, which sits below this element on the periodic table. For the point, name this precious metal with atomic symbol Ag.

ANSWER: **silver** (prompt on Ag)

(Tossup 14) Because of her performance at one of these events, an asteroid is named for Alexandria Ocasio-Cortez. The most prestigious award at one of these events is named for the creator of Moore's law. The youngest winner at one of these sponsored by Google invented a bandage embedded with graphene nanoparticles. The 2019 winner of the Intel competition of this type built an augmented-reality system to improve spinal surgery. For the point, name this type of competition in which students traditionally display their hypothesis and data on a tri-fold board.

ANSWER: **science fair** (accept specific examples like the **Intel Science and Engineering Fair**)

(Tossup 15) This faculty is impacted in the birth defects atresia and microtia, which are commonly inherited together. This sense comes in conductive and sensorineural components. The basilar membrane divides this sense into its components by activating the Organ of Corti's appropriate hair cells. The electrical signals of this sense are transmitted by the cochlea. For this sense, the incus, malleus, and stapes provide amplification to vibrations picked up from the tympanic membrane. For the point, name this sense perceived by the ears.

ANSWER: **hear**ing (or **auditory** perception; accept reasonable equivalents like **listen**ing)

(Tossup 16) A theorem named for this man and Euler states the connection between Mersenne primes and perfect numbers. This man's lemma states that a prime number that divides the product of two integers must divide one of the integers, and this man also theorized that there are infinitely many primes. This mathematician's work in geometry includes a system of proof based on five postulates, such as the parallel postulate. For the point, name this ancient Greek mathematician who wrote the *Elements*.

ANSWER: **Euclid** of Alexandria

(Tossup 17) By the Haldane effect, hemoglobin carries this molecule more readily in low presence of oxygen. The concentrations of this molecule have been measured at Mauna Loa Observatory since 1958 and plotted on the Keeling Curve. Water and this molecule in supercritical form are one way of extracting caffeine from coffee beans. The solid form of this molecule is dry ice. For the point, name this linear molecule, the most significant greenhouse gas which is produced alongside water in combustion reactions.

ANSWER: **carbon dioxide** (accept **CO_2**)

(Tossup 18) These phenomena often weaken in a process called "roping out," which is the result of conservation of angular momentum. These phenomena are made possible by a rear-flank downdraft, as studied by Ted Fujita [foo-JEE-tuh] in his "recycling hypothesis" for the generation of these phenomena. Detection of these phenomena when rain-wrapped may be possible by looking for a hook echo on radar. For the point, name this type of natural disaster, a rotating column of air that may develop from a severe thunderstorm cell.

ANSWER: **tornado**es

(Tossup 19) An operator named for reversing this operator can be used to determine doubly degenerate energy levels with Kramer's theorem. The reversal of this quantity could make a hypothetical "white hole." Arthur Eddington developed a problem referred to as the "arrow of [this quantity]" since it appears to be one directional. The chronon is a hypothetical particle that carries this quantity, which can be thought of as a fourth dimension paired with three spatial dimensions. For the point, name this quantity whose SI unit is the second.

ANSWER: **time** (accept **time**-reversal; prompt on T)

(Tossup 20) Dr. Martin Pall has proposed that electromagnetic fields such as WiFi are a potential cause of this condition. Vilayanur S. Ramachandran developed the "Broken Mirrors" theory to explain this condition in terms of dysfunctional neurons. Along with schizophrenia, Bruno Bettelheim claimed this condition was caused by "refrigerator mothers." Leo Kanner's study of this condition was later challenged by Hans Asperger. For the point, name this neurodevelopmental disorder on a namesake spectrum.

ANSWER: **autism** (prompt on Asperger's Syndrome before "Asperger")

(Tossup 21) CRCS can be used to reduce fine generation during this procedure, although more expensive ceramics are often used below 8,000 feet. In softer formations, an overloading of proppants can help to increase the conductivity of this procedure by avoiding closure. Additives such as polyacrylamide are part of the "slickwater" used in this procedure to promote fast outflow. For the point, name this procedure which relies on injection of fluids into rocks to create wells used to obtain fossil fuels.

ANSWER: **fracking** (accept **hydraulic fracturing**)

(Tossup 22) The solution to the Basel problem is this number squared divided by 6. The number e raised to the power of the product of this number and i equals negative 1, according to Euler's identity. Lambert proved that this number was irrational and sketched a proof of its transcendence. In geometry, 360 degrees is exactly twice this number of radians. This number is the exact ratio between the circumference and diameter of a circle. For the point, name this number which is approximately 3.14159.

ANSWER: **pi**

(Tossup 23) The acceleration in one type of this device is proportional to the difference of the masses over the sum of the masses; that version of this device is called an Atwood machine. These devices are linked into a block and tackle system to increase mechanical advantage. Among Hero's six simple machines are lever, wheel and axle, inclined plane, wedge, screw, and this device. For the point, name this simple machine which consists of a wheel around which a cable is wrapped to lift up objects.

ANSWER: **pulley** (prompt on Atwood machine before mentioned)

(Tossup 24) Juveniles of these animals, known as parr, are equipped with a camouflaging pattern of stripes which they lose upon becoming smolt. These anadromous animals are known for their namesake "run," which is believed to be part of the reason they are a keystone species in the Pacific Northwest. These animals are often fed carotenoids when farmed to improve the color of their flesh. For the point, name these fish, which swim upstream to spawn, that are often used to make orange-colored sushi.

ANSWER: **salmon**

(Tossup 25) Oneirology is the scientific study of these phenomena. Composites known as interobjects may appear during these phenomena. One theory proposes that these phenomena help to process and 'clean up' memory. The lucid type of this phenomenon is under some active control of the person experiencing it. The interpretation of these phenomena was a major subject of study for Sigmund Freud. For the point, name this phenomenon in which a person experiences visions and other sensations, typically during REM sleep.

ANSWER: **dream**s

(Tossup 26) One component of this landmass is the Kaapvaal craton, and 1.7 billion years ago, what is now this landmass was home to a naturally-occurring fission reactor. The splitting of this landmass has already begun in its Afar Depression. In the summer of 2018, a large dust cloud originating on this continent traveled across much of the United States, and the earliest hominid fossils have been discovered in its Great Rift Valley. For the point, Lake Victoria and the Kalahari Desert are located on which second-largest continent on Earth?

ANSWER: **Africa** (accept **Vaalbara** until "1.7")

(Tossup 27) In theory, a black hole can generate an oscillating Rosetta one of these things. Using conic sections, Carl Friedrich Gauss calculated one of these things that permitted the rediscovery of Ceres. Venus has the least eccentric one of these, while those of Neptune and Pluto intersect. A satellite with a period matching Earth's rotation has a geosynchronous one of these paths. For the point, give this term for the path a planet takes around a star.

ANSWER: **orbit**

(Tossup 28) Monochlamydeous plants typically lack these structures, Lying above the calyx, the corolla is made up of these structures, and it may surround a brighter corona, such as in the *Narcissus*. When these structures are indistinguishable from sepals, they are called tepals. Located above the sepals are, for the point, what colorful and often fragrant parts of a flowering plant which attract pollinators?

ANSWER: **petal**s

(Tossup 29) This quantity is plotted on the x-axis of a Pourbaix diagram. Proteins have neutral charge at a value of this quantity called the isoelectric point. Lime is used to increase this quantity in soil, and buffer solutions can be used to maintain a relatively constant value of this quantity during chemical reactions. Phenolphthalein turns pink above 8.5 for this quantity, such as in a solution of baking soda. Calculated as the negative log of hydrogen ion concentration, for the point, name this measure of acidity that is 7 for pure water.

ANSWER: **pH**

(Tossup 30) In Shoreham, New York, this engineer designed the Wardenclyffe Tower, intended to transmit messages across the Atlantic to England. Alfred Brown and Charles Peck started a company with this scientist which got off the ground with a patent for a polyphase induction motor that was licensed to George Westinghouse. This man replaced the insulator in a Ruhmkorff coil with an air gap to create his namesake coil, known for discharging violet-colored light. For the point, name this Serbian-American inventor and engineer, honored with the SI Unit of magnetic flux.

ANSWER: Nikola **Tesla**

Backup

(Tossup 31) This layer contains most of the mass of the atmosphere, including most of its water vapor. Hadley cells and Ferrel cells lie within this region of the atmosphere, and their tops are defined by the inversion layer lying above this layer of the atmosphere. At the bottom of this layer is the planetary boundary layer, where absorbed heat is radiated back into this layer, making it warmest near the bottom. For the point, name this layer of the atmosphere in which weather takes place nearest to the Earth's surface.

ANSWER: **troposphere**

(Tossup 32) This country operated both the Buran shuttle program and Venera probes from Baikonur. Among this nation's most successful vehicles was the Soyuz, and its Mir station continued to operate until 2001. Pioneers from this country included Valentina Tereshkova and Laika the dog, and its pilot Yuri Gagarin was the first person to leave Earth's atmosphere. Launching Sputnik in 1957, for the point, name this former country whose cosmonauts competed against Americans in the space race.

ANSWER: **Soviet Union** (accept **USSR**; prompt on Russia until "Baikonur," which is in Kazakhstan)