

Science Monstrosity III: The Gay Science  
Round 2

Berkeley  
Paul Lujan

July 2, 2005

## 1 Berkeley Tossups, Round 2

1. The third Dihedral Group is isomorphic to the third of these groups, and that group is the smallest non-commutative group. For  $N > 3$ , the  $N^{\text{th}}$  Dihedral Group is a proper subgroup of the  $N^{\text{th}}$  of these groups, since the dihedral groups represent the rotations and reflections on an  $N$ -sided polygon. The normal subgroup of this group consisting of elements with signature 1 is called the alternating group. The order of the  $N^{\text{th}}$  of these groups is  $N$  factorial, and Cayley's Theorem, of more theoretical than practical interest, shows that any finite group of order  $N$  is a subgroup of the  $N^{\text{th}}$  of these groups, since any group's operations on itself can be represented as a permutation on  $N$  objects. For ten points, identify this class of groups, consisting of all possible permutations on  $N$  objects.

**Answer:** Symmetric Groups

2. In quantum mechanics, the product of its uncertainty and any operator is proportional to the time derivative of the operator, and if it commutes with a given operator, that operator's expectation value is thus conserved. In classical mechanics, it is given by the product of the canonical momentum and the time derivative of the generalized coordinates minus the Lagrangian. For ten points, what is this operator, most commonly associated with the energy of a system?

**Answer:** Hamiltonian or H

3. The largest phylum found only in sea water, members of this phylum are distinguished by their water vascular system used for locomotion and feeding. They are deuterostomes like their closest relatives, the Chordata, but possess only secondary bilateral symmetry, as their primary symmetry is radial and usually fivefold. For ten points, what is this phylum, consisting of classes such as sea cucumbers, starfish, and sea urchins?

**Answer:** Echinodermata or echinoderms

4. When added to epsilon-zero times the electric field, the electric displacement  $D$  is obtained, allowing one to eliminate bound charge from Gauss' Law, as the negative of its curl is equal to the bound charge. If it is not in the same direction as the electric field, this requires the electric susceptibility to be a tensor, while in an isotropic medium it is equal to the susceptibility times epsilon-zero times the electric field. For ten points, what is this quantity that describes the movement of charge in a dielectric due to an applied electric field?

**Answer:** Electric Polarization

5. Odd Hassel won a Nobel Prize for his work on this compound. Its two stable conformations differ in energy by 23 kJ/mol, with an activation energy of 45 kJ/mol to go from one to the other. One of its conformations exhibits little torsional strain but the "flagpole interaction" decreases its stability, while its most stable conformation has C-C bond angles very close to 105 degrees. For ten points, what is this alkane which can be found in the twist, boat, or chair conformations, with formula  $C_6H_{12}$ ?

**Answer:** Cyclohexane

6. The angular frequency associated with them at the cutoff for the  $n^{\text{th}}$  higher mode is given by the product of the mode number and  $\pi$  over  $H$  times 1 over the square root of the difference in the inverse squares of velocity constants  $\beta_1$  and  $\beta_2$  during propagation. Their particle motion is toroidal and always perpendicular to the propagation vector, and may be found on the transverse record of a seismogram. For ten points, name these dispersive surface waves that form from constructive interference of S-wave reflections between trapping layers, which arrive at a seismograph just prior to Rayleigh Waves.

**Answer:** Love waves

7. For a set of  $d$  pseudo-real representations of scalars, this symmetry is  $Sp(2d)$ . In the Standard Model, neutral currents that change this property are exceedingly rare, meaning that most frequently, changes in it are accompanied by the emission of a  $W$  boson. The matrix describing its mixing in the quarks is known as the Cabibbo-Kobayashi-Maskawa, or CKM, matrix, and its small off-diagonal terms are responsible for the long lifetimes of strange particles like the  $K$  mesons. Conserved by the strong interaction, For ten points, what is this property of particles which describes their content of up, down, charm, strange,

bottom, or top, although not their taste?

**Answer: Flavor**

8. Pencil and paper ready. Suppose you wanted to compute the remainder when you divide  $2^{35}$  by seven.  $2^{35}$  is a really big number, but you can write  $35 = 6 * 5 + 5$ . By applying Fermat's little theorem, we can remove much of the exponent since  $2^6$  must be congruent to 1 in the equivalence class mod seven, which leaves only to compute  $2^5(mod7)$ . For ten points, give the remainder of 32 divided by seven.

**Answer: 4**

9. Flanders and Swann attempted to illustrate it with a box filled with tangled wires; only by moving them outside the box could they become untangled. Kelvin and Planck defined it for a device that operates on cycles working from a single reservoir, but more famous is the 1871 thought experiment, debunked by Szilárd and Bennett, that attempted to create a system without energy inputs such that the overall organization increased. In 1850, Clausius gave the canonical definition that heat does not spontaneously aggregate for – for ten points– what law of thermodynamics that states that entropy only increases with time?

**Answer: Second law of thermodynamics**

10. The coracoid process is attached to its upper portion and serves as the site of attachment for the pectoralis minor muscle, while the acromion extends off to its side and above the glenoid cavity, which is the point of its articulation with the humerus. The acromion, meanwhile, is connected to its other neighbor, the clavicle. For ten points, what is this bone which is informally known as the shoulder blade?

**Answer: scapula**

**prompt on “shoulder” or “shoulder blade” before the end**

11. Rasmus Lerdorf's original version had “forms interpreter” appended to its name for its second 1997 release written in C with a Perl-like (albeit inconsistent) syntax and vastly expanded for its first widespread version, Version 3. Higher performance and modularity were achieved in the next version by using the Zend engine; when viewing the webpage for the info on the package on April 1, the page either displays a guy with chopsticks, a bunny, or a dog. For ten points, what is this web scripting language with a recursive acronym, an alternative to languages like JSP, ASP, and Perl?

**Answer: PHP or PHP Hypertext Preprocessor**

12. A tertiary alkyl halide sterically hinders substitution as well as the multiple molecules involved in a concerted reaction. The removal of the halide and formation of a carbocation is the first and the rate-limiting step. The protic solvent, often alcohol, usually acts as the weak base in the second step, deprotonating that carbocation to form an alkene. For ten points, what is this two-step reaction where two groups are removed from a molecule?

**Answer: E1 or unimolecular elimination**

13. Hoffmann-La Roche holds the patent on this process, and the first machine to automate this process, developed by Cetus, automatically added more enzyme since the enzyme was destroyed by the high temperature required to denature its substrate. This problem was overcome by the use of *Thermus aquaticus*, or Taq, enzyme, which would remain stable through many heating and cooling cycles. More recently there is also a “real time reverse transcription”, or RT, version of this technique. For ten points, what is this method developed by Kary Mullis, used to amplify large quantities of DNA?

**Answer: Polymerase Chain Reaction**

14. It was first observed by Maraldi, whose results were unknown to Dominique Arago, a judge for the Grand Prix of 1819, whose name is sometimes attached to the phenomenon observed while testing a hypothesis proposed by the man whose name is most commonly attached to it. Its existence comes theoretically from the fact that the Bessel function has a maximum at 0, which led an advocate of the particle theory of light to conclude that the wave interpretation was flawed, since he did not like Fresnel's theory of diffraction. For ten points, what is the name given to the spot at the center of a diffraction pattern behind a circular object?

**Answer: Poisson's spot**

**Prompt on early “Arago” spot**

15. A 1973 study by Gatewood and Eichhorn failed to reproduce observations of a gravimetric wobble in this astronomical body claimed by Peter van de Kamp, who had postulated that it was orbited by at least one gas giant. Located at Right Ascension 17 hours, 57 minutes, 50 seconds, declination 4 degrees, 38 minutes, 19 seconds, it is a red dwarf that appears just west of Cebalrai of apparent magnitude 9.54, and it is distinguished for having a proper motion of 10 arcseconds per year, the largest of any known star. For ten points, what is this star located in Ophiuchus lying a mere 5.9 lightyears away from Earth, making it, aside from the Centauri system, the closest star to the Sun?

**Answer: Barnard's star**

16. Its eponymous lattice consists of two face-centered cubic lattices shifted  $1/4$  along the length of the body diagonal, with each atom covalently bonded to four atoms in the other lattice. Though its decay is thermodynamically favorable, the very high activation energy means that for all practical purposes, it will never change into the other allotrope. Nikolai Polushin helped develop a synthetic system that is currently being marketed by Gemesis. For ten points, what is this extremely thermally conductive, insulating, and hard allotrope of carbon?

**Answer: Diamond**

17. When using this, impurities are removed by the chemical action of the flux, which can be borax, zinc chloride, or ammonium chloride, but is most commonly rosin. The common ratio of 60/40 is chosen to give the mixture a near-eutectic point, so it will melt more easily, but one of the components is currently being phased out despite its usefulness, due to its toxicity. For ten points, what is this material, commonly made out of tin and lead, used to create electrical connections between two pieces of metal?

**Answer: Solder**

18. Cyanide is poisonous because it binds to one of these compounds, interrupting the process that they are members of. Coenzyme QH2 passes electrons to the *b* type of this protein, which passes electrons to an iron-sulfur protein, which passes the electrons to the *c1* type, which passes them to the most famous *c* type. *c* is a small mobile protein that transfers electrons between Complex III and IV in the inner membrane of mitochondria. Therefore, a release of it into the cytosol can signal a cell for apoptosis. For ten points, name this group of proteins containing heme rings and are in the electron transport chain.

**Answer: Cytochromes**

19. Hardy and Littlewood first showed that the generalized Riemann hypothesis could be used to prove the weak version of this for sufficiently large numbers, while Ivan Vinogradov proved it without the assumption for numbers greater than approximately 10 to the 6 million. Schnierlmann proved that it could be done by using at most 300,000 primes, slightly larger than the 2 originally stated in the conjecture. For ten points, what is this conjecture stating that every even number greater than 2 can be expressed as the sum of two primes?

**Answer: Goldbach conjecture**

20. They are enclosed at their outermost boundary by the Chapman-Ferraro Cavity. Streams called Birkeland Currents connect them, and extend to their lowest height over the South Atlantic Anomaly. Their inner members are made up of energetic protons produced by cosmic rays, while the outer section is a plasma consisting mostly of electrons trapped by the magnetosphere. Extending to a radius of about 65,000 km, For ten points, what are these radiation belts centered around the equatorial plane of the Earth?

**Answer: Van Allen belts**

## 2 Berkeley Bonuses, Round 2

1. Answer these questions about conductivity in metals for ten points each.

10 What basic model of conductivity treats the electrons as a classical gas with some damping force? It provided fairly good results despite its simplicity.

**Answer: Drude model**

10 Who revised the model by applying fermion statistics to the electrons, solving many of the problems with the Drude model?

**Answer: Arnold Sommerfeld**

10 In superconductors, the Cooper pairs become what type of particle, defined as particles with integer spin?

**Answer: Bosons**

2. Answer these questions about the Central Dogma of molecular biology for the stated number of points.

5,5 Loosely speaking, the Central Dogma states that these two processes, which transfer information from DNA to protein, must always take place one after the other.

**Answer: Transcription and translation**

5 These violate the first part of the Central Dogma by using reverse transcriptase to make DNA from RNA.

**Answer: Retroviruses**

5 These evade the Central Dogma by changing the conformations of proteins directly by proteins.

**Answer: Prions**

10 The transcription-translation process often has this additional step, used in eukaryotes to eliminate introns from RNA.

**Answer: Splicing**

3. Identify these parts of the Earth's interior for ten points each.

10 S-waves cannot travel through this liquid area, giving rise to a shadow zone on the opposite side of the earth.

**Answer: Outer core**

10 Also known as the "low-velocity" zone, this part of the mantle lies below the lithosphere.

**Answer: Asthenosphere**

10 This discontinuity, named after a female seismologist, marks the dividing line between the inner and outer core.

**Answer: Lehmann discontinuity**

4. Answer these questions about Edsger Dijkstra for ten points each.

10 Dijkstra is most well-known for his eponymous algorithm solving this problem for a directed graph with weights.

**Answer: single source Shortest path problem**

10 Dijkstra is also famous for his 1968 article decrying this instruction as "harmful", although Niklaus Wirth actually gave the article its title.

**Answer: GOTO**

- 10 Dijkstra used this classic thought experiment of processes as “hungry,” “eating,” or “thinking” as a way of motivating synchronization problems.  
**Answer: Dining philosophers problem**
5. Answer these things about everyone’s favorite reaction series, Bowen’s reaction series for ten points each.
- 10 The discontinuous branch contains this kind of heavy-element-rich minerals.  
**Answer: Mafic**
- 10 At the lowest-temperature end of the reaction series, before the split into the two branches, is this simple silicate.  
**Answer: Quartz**
- 10 The continuous branch consists of various kinds of plagioclase. For ten points, what element is found more predominantly at the higher-temperature end of the continuous branch?  
**Answer: Calcium**
6. Identify these subunits of phylum Arthropoda for the stated number of points.
- 5 This very extinct arthropod class is named for their three lobes.  
**Answer: Trilobites or Trilobita**
- 5 This subphylum contains delicious species like lobsters, crabs, and shrimp. Also barnacles.  
**Answer: Crustaceans or Crustacea**
- 10 Insects are placed in this subphylum, whose name refers to the feature that distinguishes them from arachnids, centipedes, and millipedes.  
**Answer: Hexapods or Hexapoda**
- 10 Some claim that this order of Arachnida should be its own sister class to the arachnids. They are distinguished by their large claws, or pedipalps, and long segmented tail.  
**Answer: Scorpions or Scorpiones or Scorpionida**
7. Name the B-complex vitamin for the stated number of points.
- 5 Also known as cyanocobalamin or extrinsic factor, its deficiency causes anemia.  
**Answer: B-12**
- 5 This vitamin has been gaining popularity thanks to its important role in successful pregnancies.  
**Answer: B-9 or Folic acid**
- 10 Deficiency in this vitamin causes beriberi.  
**Answer: B-1 or Thiamine**
- 10 This B-complex vitamin is necessary to prevent pellagra.  
**Answer: B-3 or Niacin or Nicotinic acid or Nicotinamide or Niacinamide**
8. Given an invariance, provide the quantity that Nöther’s theorem says is conserved by that invariance for ten points each.
- 10 Spatial translation  
**Answer: Linear momentum**
- 10 Time translation  
**Answer: Energy**
- 10 Electromagnetic gauge transformations  
**Answer: Electric charge**
9. Identify these parts of, or things attached to, the heart for the stated number of points.

- 5 This largest artery carries blood flowing out of the heart.  
**Answer: Aorta**
- 10 This is the chamber from which blood is pumped into the aorta.  
**Answer: Left ventricle**
- 5 This artery carries deoxygenated blood out from the right ventricle.  
**Answer: Pulmonary artery**
- 10 These two valves prevent blood from flowing from the pulmonary artery or the aorta back into the heart.  
**Answer: left and right semilunar valves**
10. Identify these points in a triangle for ten points each.
- 10 The center of mass of a uniform triangle, this point is defined by the intersection of the three medians.  
**Answer: Centroid**
- 10 This point, the intersection of the angle bisectors, is the center of the inscribed circle of the triangle.  
**Answer: Incenter**
- 10 This point midway between the circumcenter and orthocenter is the center of an eponymous circle.  
**Answer: Nine-point center**
11. Given how it flagrantly violates the laws of physics, name the Star Trek technology for ten points each.
- 10 It uses “Heisenberg Compensators” to be able to directly copy both the momentum and position of particles in its matter stream.  
**Answer: Transporter**
- 10 It uses an energy beam to impart momentum to another ship, but the ship using it doesn’t move at all.  
**Answer: Tractor beam**
- 10 These keep the crew from being crushed while the ship is accelerating or moving rapidly. Even so, they frequently fail when it’s handy for the script.  
**Answer: Inertial dampers**
12. Everyone’s sick of Periodic Table chess, so here’s a slightly different periodic table game. Given six elements, tell me which one doesn’t belong with the other five for ten points each.
- 10 Lithium, potassium, strontium, rubidium, francium, cesium  
**Answer: Strontium**  
**is an alkaline earth; the others are alkali**
- 10 Yttrium, dysprosium, praseodymium, samarium, cerium, ytterbium  
**Answer: Yttrium**  
**is a transition metal; the others are rare earths**
- 10 Rhenium, palladium, iridium, rhodium, thallium, hafnium  
**Answer: Thallium**  
**is group IIIa; the others are transition metals**
13. Answer these questions about the humble op-amp for the stated number of points.
- 5,5 For five points each, name the two input terminals of an op-amp.  
**Answer: Inverting and non-inverting**

- 5 For five, one of the Golden Rules of op-amp design is that the input impedance is equal to what?  
**Answer: Infinity**
- 5 For five, the other Golden Rule is that the voltage difference between the two input terminals is what?  
**Answer: Zero**
- 10 For a final ten, take an op-amp, ground the non-inverting terminal, and attach an input voltage in series with a resistor to the inverting terminal. Wire a capacitor between the output and the inverting input. What device have you produced?  
**Answer: An Integrator**
14. Identify these things about the Bohr model of the hydrogen atom for ten points each.
- 10 The Bohr model is derived by assuming that this quantity is quantized in units of  $h$ -bar.  
**Answer: Orbital angular momentum or  $L$**
- 10 This assumption can be justified by noting that it is equivalent to assuming that the circumference of the electron orbit must be an integer multiple of this quantity.  
**Answer: de Broglie wavelength**
- 10 This term in the Bohr model with units inverse meters is given in terms of five fundamental constants: the charge and mass of an electron,  $\epsilon_0$ ,  $h$ , and  $c$ .  
**Answer: Rydberg constant**
15. Given a process for an ideal gas, tell whether the internal energy of the gas will be increased, decreased, or remain the same for ten points each.
- 10 Isothermal expansion  
**Answer: Stay the same or equivalent**
- 10 Adiabatic expansion  
**Answer: Decrease**
- 10 Isobaric expansion  
**Answer: Increase**
16. Given a derivative of benzene, tell what functional group must be added to obtain that derivative for ten points each.
- 10 Phenol  
**Answer: hydroxyl or OH**  
**accept also alcohol**
- 10 Aniline  
**Answer: amino or  $\text{NH}_2$ , do not accept amine - that's not a group**
- 10 Styrene  
**Answer: Ethenyl, also accept  $\text{C}_2\text{H}_3$ ,  $\text{C}_2\text{H}_4$ , ethene, ethylene, or vinyl**
17. Clifford Cocks did it first, but got no credit because it was classified. For ten points each. . .
- 10 Name this public-key system extended from the theoretical work of Diffie and Hellman in 1976.  
**Answer: RSA or Rivest-Shamir-Adleman**
- 10 In RSA, we publish the number  $m$ , which is the product of two primes  $p$  and  $q$  that only we know. The difficulty is that others cannot efficiently compute  $\phi(m)$ . What is the value of  $\phi(m)$  in terms of  $p$  and  $q$ ?  
**Answer:  $(p-1)(q-1)$**   
**accept algebraic equivalents**

10 The function  $\phi$  is the totient function of what mathematician?

**Answer: Leonhard Euler**

18. Given the first three color bands of a standard resistor, give the resistance of the resistor, in ohms, for ten points each.

10 Brown, black, black

**Answer: 10 ohms**

10 Brown, black, green

**Answer: 1,000,000 or 1M ohms**

10 Yellow, violet, red

**Answer: 4700 or 4.7k ohms**

19. Given a function, calculate its residue at  $z = 0$  for ten points each.

10  $1/(z(z-1))$

**Answer: -1**

10  $e^z/z^2$

**Answer: 1**

10  $1/z^2$

**Answer: 0**

20. Identify these important times in the evolution of the universe for ten points each.

10 Occurring at a redshift of approximately 1100, the cosmic microwave background was produced at this time when the temperature dropped low enough to allow neutral hydrogen to form.

**Answer: Recombination**

10 Reversing recombination was this process, occurring at a redshift of approximately 6, when the first stars began to shine through the universe.

**Answer: Reionization**

10 Before this time, the scale factor of the flat universe goes as  $t^{1/2}$ ; afterwards, it evolves as  $t^{2/3}$ .

**Answer: Matter-radiation equality or similar**