Every question, except those categorized as "Electrician/Electrical Safety", has a 3-letter code indicating, in order:

- *difficulty at which I would place it as a tossup (B: Regs, C: Regs+, D: Nats, E: CO, F: Nowhere)*
- *by what year I would expect an EE major to learn about the answer (5 being in a graduate program)*
- *where I personally learned about the answer (C: Class, O: Outside of class, T: Tournament, for this).*

Tossups rated "F" have 20-point powers. All others have 15-point powers. All questions are worth 10 points after power.

1. **An "extended" version of this method that can be applied to nonlinear systems linearizes about the current mean and covariance. The namesake "gain" or "blending factor" used in this method is a**
3 **matrix that minimizes the *a posteriori* error covariance. This method is combined with the linear quadratic regulator to solve the linear quadratic Gaussian control problem. This method is used for systems with a state vector equal to the state transition matrix times the state vector plus the control**
6 **matrix times the control vector plus the process noise vector, and an observation vector equal to the observation matrix times the state vector plus the measurement noise vector. It has two phases, predict and update, and it grew out of a paper in which a recursive solution to the discrete-data linear**
9 **filtering problem was found. For 10 points, name this purely time-domain (*)** filter that provides an optimal estimate for many linear stochastic systems.
ANSWER: **Kalman** filter [prompt on: **linear quadratic estimator**, **LQE**] – E5O

2. **This paper prominently mentions, but refers one to a separate paper for a description of, Karn's algorithm for backing-off the RTO to obtain a more accurate "smoothed" RTT. An algorithm described**
3 **in this paper sets a cwnd variable to 1 and increases it by 1 for each ack. That algorithm, the somewhat misnomered "slow-start", is used in conjunction with an algorithm that halves cwnd when a timeout occurs, allowing for dynamic window sizing. The final section of this paper notes that only gateways**
6 **are suitable for ensuring fair sharing of capacity. The main sections of this paper are ordered as a response to three conditions: the connection not getting to equilibrium, a sender injecting a new packet before an old packet has exited, and equilibrium not being reached due to resource limits**
9 **along the path. This paper describes five of the seven algorithms put into the BSD (*)** TCP stack to ensure the implementation of the protocol obeyed "conservation of packets", as a way to eliminate its title phenomenon. For 10 points, name this seminal paper by Michael J. Karels and Van Jacobson, which was
12 motivated by the 1986 collapse of the Internet due to the title phenomenon.
ANSWER: "**Congestion Avoidance and Control**" – F5T

3. **This quantity can be determined by performing UV/Vis/NIR spectroscopy on a sample to determine the wavelength when the absorbance jumps, then dividing 1,240 by that wavelength, in nanometers.**
3 **The temperature dependence of this quantity is described by subtracting A T squared over quant. B plus T, end quant. from its zero Kelvin value, according to the famous Varshni equation. This quantity determines the wavelength of emitted photons in LEDs and laser diodes. Whether or not the min. and**
6 **max. that determine this quantity are at the same value of (*)** crystal momentum determines whether a semiconductor is indirect or direct. For 10 points, name this energy by which the conduction band and valence band are separated.
ANSWER: **bandgap** – C3C

4. **When analyzing random processes, a good assumption is that they are ergodic in the mean and in this quantity. For an autoregressive–moving-average model, a relationship between the autoregressive** *3* **coefficients and this quantity is established by the Yule-Walker equations. By transforming a random process to the frequency domain and taking the conjugate of one term, one can easily compute this quantity via convolution. Wide-sense stationary processes are important because their value for this** *6* **quantity only depends on the difference in time, τ, which allows one to use the Wiener-Khinchin theorem to derive the (*)** power spectral density of a random process as the Fourier transform of this quantity. For a random process X, this quantity is defined as the expectation value of quantity $X(t_1) \times X(t_2)$. *9* For 10 points, name this quantity symbolized R_{XX} that is defined as the cross-correlation of a signal with itself.
ANSWER: **autocorrelation** [prompt on: cross-**correlation**] – D3C

5. **A theorem due to this person states that if a transfer function, L, has a difference in degree between denominator and numerator greater than one, then the integral of the log magnitude of the reciprocal** *3* **of $1 + L$ is zero over the entire frequency range. As the reciprocal of $1 + L$ is known as the sensitivity function, said theorem is his sensitivity integral theorem. A very complicated relation due to this man, oddly involving the hyperbolic cotangent, basically states that the phase of a stable, minimum** *6* **phase transfer function is uniquely determined by the slope of its magnitude and is thus appropriately known as his (*)** gain-phase relation. For 10 points, name this Dutchman famous for the magnitude/phase vs. log-frequency graphs commonly used to depict transfer functions for LTI systems.
ANSWER: Hendrik **Bode** – D2C

6. **An article about the invention of this arrangement claims that it is now commonly used to "actuate solenoid-driven flippers and flashing lights in electromechanical pinball machines". This arrange-** *3* **ment is also somewhat prevalent, at least as an example in academia, in the output stages of Class AB amplifiers, which are mainly used for audio. This arrangement differs from the superior Sziklai arrangement in that its constituent devices have the same polarity. At high frequencies, this arrange-** *6* **ment induces a high phase shift that is not correctable with negative feedback. A disadvantage of this arrangement is the doubling of the voltage drop, to about 1.4 V for silicon-based devices. The gain of this arrangement is equal to (*) $\beta_1 + \beta_2 + \beta_1\beta_2$,** or just β^2 for any moderately high beta. For 10 points, *9* name this arrangement where the emitter of one BJT is connected to the base of another.
ANSWER: **Darlington** transistor pair [or: **super-alpha** pair] – E2C

7. **The third and fourth tables, C and D, in the ITU's G.652 specification have requirements for the reduction of this problem, G.652.D being the defacto standard. The vapor axial deposition process is** *3* **most often used to address this problem, as plasma CVD, modified CVD, and outside vapor deposition all require a high temperature when collapsing the annulus they form. This problem appeared after the move to coarse wavelength division multiplexing used the entire transmission band from 1271 to** *6* **1611 nm; CWDM can be bumped to 16 channels if this problem is addressed by (*)** ZWPF and LWPF. This problem creates spikes in a wavelength vs. attentuation curve at 950, 1244, and – most importantly – 1383 nm. For 10 points, name this optical fiber problem in which an ion found in water creates peaks in an *9* optical fiber's attentuation curve.
ANSWER: **OH**- absorption [or: **OH**- contamination, obvious equivalents mentioning **OH**-; until "water" is read: **water** molecule peak absorption, **water** contamination] – F5C

8. **This program is used by, at the least, RIT, whose Lynn Fuller has prepped an excellent set of instructions for it, and VCU, in our Solaris lab. You should really save intermediate and final results of**
3 **this program, which is done using the `struct outfile` command and defining a filename with the extension `.str`. The output of this program is often used as an input to its company's ATLAS program, which also uses TONYPLOT for visualization. Results from this program can be obtained by**
6 **feeding the appropriately named "extract" command to its script interpreter, DECKBUILD. Scripts for this program always start by defining a grid, after which commands such as `diff`, `deposit`, `etch`, and `implant` can be used. This 2D TCAD program is a commercialization of Stanford University's SUPREM.**
9 **For 10 points, name this process simulation software offered by Silvaco and named for a (*)** Greek goddess.
ANSWER: Silvaco **ATHENA** – F5C

9. **When using a cascaded integrator-comb filter for this process, as proposed by Hogenauer, the integrator comes before the comb filter. A filter named for this process is applied directly before the output**
3 **in a sigma-delta analog-to-digital converter; said filter also transforms the 1-bit input to 16-bit. Signal flow graphs resembling butterflies are used in conjunction with twiddle factors to implement the fast Fourier transform by decomposing an N point DFT by dividing the input sequence in two in the radix-2**
6 **version of the [this process]-in-time algorithm. The first step of this process is to use a low-pass filter, often a block averaging or a sinc filter, with a cutoff frequency of the sampling rate over twice the namesake (*)** factor of this process, represented M. It is basically the opposite of interpolation. For 10 points,
9 name this process in which the sampling rate of a signal is reduced.
ANSWER: **decimation** [prompt on: **downsampling**, **rate reduction**]– E4C

10. **Judging by the C code for the final lab in my DSP class, one should use 205 bins when using the discrete Fourier transform to demodulate this system because then the frequency centers of the bins**
3 **are most closely aligned to this system. Also, a very useful and popular DFT algorithm for use with this system is the Goertzel algorithm. This system is represented by a 4 x 4 matrix whose rows are (*)** 697, 770, 852 and 941 Hz and whose columns are 1209, 1336, 1477, and 1633 Hz. For 10 points, name
6 this system in which numbers and symbols are encoded as a combination of a low and high frequency, for transmission over a telephone network.
ANSWER: **DTMF** [or: **dual-tone multi-frequency** signaling] – E4C

11. **Riedmiller and Braun's adaptive variant of this method uses the Manhattan method. Silva and Almeida's variant of this method includes the multipliers u and d, which should be greater and less**
3 **than 1, respectively. This method can be extended to recurrent and Elman networks by unfolding them "through time". A common way to speed up this method and avoid excessive oscillations is to include the "momentum term". This method rose to power following the 1986 publication of a paper**
6 **by (*)** Rumelhart, Hinton, and Williams. It's often combined with a sigmoid activation function. This method is applied to networks with an input layer, one or more hidden layers, and an output layer, where each layer only feeds to the next, and it updates weights based on the gradient of the quadratic error function. For 10
9 points, name this very famous learning method that's applied to feedforward networks.
ANSWER: **backpropagation** [prompt on: **gradient descent** method]– D4C

12. **A problem with this code is the existence of an "error floor" – the bit-error probability decreases dramatically for low numbers of e-b over N-o, but then levels off sharply, which is due to its poor**
3 **minimum distance. This code is a class of concatenated codes whose inner and outer codes are, typically, recursive systematic convolutional codes that are, always, (*)** interleaved. This code has unparalleled performance at very low SNRs, allowing one to get within a fraction of a dB of the Shannon
6 limit on channel capacity. For 10 points, identify this forward-error-correcting code that one would assume is very fast.
ANSWER: **turbo** code – F5O

13. *Note to moderator: please check the answerline carefully – note the acceptance of a pluralized form, but a prompt on non-pluralized. This is intentional.*
According to a co-worker of mine, this implement by this company is useful as a projectile if squirrels are eating the carpet on your pontoon boat. Non-standard uses of this implement include its use as a plumb bob and as a weight for a pull string when thrown in the ceiling, as well as for punching out sheetrock before cutting it. Although not a conduit reamer, this implement by this company is frequently used to ream half inch and three-quarter inch EMT conduits. This implement by this company is approximately nine inches long, thus the common nickname "nines". It was first devised for a telegraph linesman in 1857, making it both the first tool made by its company and, by far, the most famous. Its embossed, circular pivot is quite often used to pound things in, to drywall and otherwise, earning it the nickname of an "electrician's hammer". Perhaps its most common use is to strip two or more wires and then (*) twist them together before putting on a wire nut. For 10 points, identify this electrician's "swiss-army knife" with a knurled jaw used to grip things and made by a company that no one, not even Chris Ray, could confuse with a company founded by a fashion designer named "Calvin".
ANSWER: pair of **Kleins** [or: **Klein** side-cutting **pliers**, **Klein** linesman **pliers**, **Klein** combination **pliers**; until it is read: **nines**; prompt on: **Klein** Tools, **pliers**; do not accept other types of pliers not explicated here, including "needle-nose pliers"; only accept other companies, such as "Craftsman", "Greenlee", "Milwaukee", "Knipex", etc. from an apprentice, journeyman, or master electrician] – N/A

14. **An important property for these things is the distance from the center to one over e-squared on their Gaussian profile, which is the namesake "field radius" for one of these things. In the classroom, it is common to approximate these things as linearly polarized, or LP, as they are more tractable to analysis. A namesake type of dispersion arises due to the propagation velocity of these things not being the same. Their number is commonly approximated as the V number squared over two & a condition for there only being one is that the V number be less than 2.405. Higher examples of these things typically penetrate further into the (*)** cladding, and they include TE, TM, EH, and HE, the latter two taking helical paths. They are the distinct azimuthal and radial distributions of the electric and magnetic field in an optical fiber. For 10 points, identify these things that split optical fibers into two classes: single-[these things] and multi-[these things].
ANSWER: **mode**s in an optical fiber – E4C

15. **A variant on this process that eliminates most of its disadvantages is the SWAMI. Another variant of this process that relieves some of the stress is prefixed poly-buffered. Even after removing the materials used in this process, it often leaves behind a white ribbon, due to nitridation of the silicon surface, which is sometimes called the Kooi effect. Even if one uses a buffer oxide under a silicon nitride layer in this process, a prominent bird's beak develops at the edges. This process has been completely supplanted by (*)** STI, shallow trench isolation. For 10 points, identify this isolation method that used to be synonymous with MOS devices and is named for its use of an oxide.
ANSWER: **LOCOS** [or: **local oxidation of silicon**] – F4C

16. **A paper published by this man, Kip, and Kittel established k dot p perturbation theory as an important empirical model. The Hamiltonian for the linear component of an interaction named for this physicist has terms where the Pauli matrix vector is multiplied by the electron momentum in the same direction. In two dimensions, D'yakonov and Perel derived the strength of that interaction named for this man as having a linear and a cubic term in electron momentum; the cubic term destroys the persistent spin helix because it breaks SU(2) symmetry. That interaction is observed in heterostructures and is driven by bulk inversion asymmetry, as opposed to a similar interaction driven by structural inversion asymmetry. For 10 points, identify this scientist whose namesake spin-orbit interaction is often paired with one named for Emmanuel (*)** Rashba.
ANSWER: Gene **Dresselhaus** – F5O

17. **The off-diagonal spin mixing of two subtypes of these particles in the Luttinger Hamiltonian gives rise to anticrossings. A split-off state of these particles, separated frrlom the origin by the spin-orbit splitting energy, exists when taking into account relativistic effects. At the gamma point, the inverse of the second derivative of energy with respect to crystal momentum, i.e. the slope, differentiates the "heavy" and "light" (*)** bands of these particles, which are akin to p-orbitals and can have m_j equal to $\pm\frac{1}{2}$ or $\frac{3}{2}$. In two dimensions, it is impossible to describe these particles with the effective-mass approximation as their dispersion is highly anisotropic and nonparabolic. These particles almost always have a lower mobility than their counterparts. Doping silicon with boron, an acceptor, creates an excess of these particles. For 10 points, name these quasi-particles created when an electron absconds.
ANSWER: electron **hole**s – C3C

18. **One typically wants one of these devices to be UL 1008 listed. A type of this device that operates as "make-before-break" ensures that two sources are synchronized, making NEC-mandated monthly testing much less onerous, and is the closed-transition type. When implementing a "separately-derived source", one must use a 4-pole example of this thing, instead of 3-pole, as overlapping neutrals aren't allowed. In the healthcare and data center markets, these devices are often used in conjunction with a (*)** bypass–isolation switch in order to allow their maintenance. For 10 points, name these devices that tell a generator to start and then transfer a subset of the building's load from utility to the generator.
ANSWER: **ATS** [or: **automatic transfer switch**; prompt on: **transfer switch**] – E5O

19. **The efficiency of devices that use this material is improved by the presence of an "ordered-defect compound" at the surface of the layer of this material. Though not InP, the devices for which this material is used incorporate it in a "double-graded" profile, so that there is a "notch" in the bandgap profile near the surface of its layer. This material is best deposited using coevaporation. Adjusting the components of this material would ideally yield a bandgap of 1.4 eV, but a 1.15 eV bandgap is the limit of current attainability due to an as-yet-unknown device performance dropoff above gallium ratios of 0.3. It is commonly deposited on molybdenum-coated soda lime glass, whose sodium ions are incorporated into this material at a concentration of less than 1% to give optimal performance. If the problems with CZTS are ever worked out, it will replace this compound. Of the compounds with a chalcopyrite crystal structure, this compound makes the best absorber layer and has the highest recorded efficiency for a (*)** thin-film solar cell; however, it is not realistically commercializable due to the scarcity of indium deposits. For 10 points, name this quaternary compound prominent for its use in thin-film solar cells, much like cadmium telluride and amorphous silicon.
ANSWER: **CIGS** [or: **Cu(InGa)Se$_2$**, **copper indium-gallium** di**selenide**; prompt on: **CIS**] – F5C

20. **Ballistic transport due to velocity saturation causes these graphs to be compressed vertically. The constant slope on these graphs can be used to find λ, the channel-length modulation. A graphical approximation when dividing these graphs into their two parts is to find the point at which the slope stops changing, though the actual division is defined by the exponential curve (*)** $v_{GS} - V_T$, which splits them into the triode and saturation regions. These graphs feature a family of curves for different gate voltage values. For 10 points, name these current–voltage graphs for MOSFETs.
ANSWER: i_D**–**v_{DS} curve [or: i_{DS}**–**v_{DS} curve, **drain current–drain voltage** curve; any order; prompt on: **I–V** curve, **current–voltage** curve] – E2C