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. **The NEMA classification of these devices splits them into A, B, C, and D based on their torque-speed curve, which – for normal resistance – decreases from its starting point to the pull-up torque, then**
   3 **increases until the breakdown torque, after which it decreases sharply. These devices are braked in a process called "plugging", which involves interchanging their phase sequence. The difference in speed at which these devices are operating and the synchronous speed is known as "slip". The**
   6 **electrical energy required to start them is quoted as the locked (*)** rotor amps. These devices are broadly divided into wound-rotor & squirrel-cage types. The current-carrying conductors in these devices lie in a rotating magnetic field such that the Lorentz force they experience drags the conductors in the direction of
   9 the magnetic field. For 10 points, name these motors based on Faraday's law.
   ANSWER: polyphase **induction** motors [or: **asynchronous** motors; prompt on: **motor**s] – F4O

2. **The time and space complexity of this algorithm can be reduced by using tail-biting and puncturing versions of the structures to which it is applied. Inclusion of an *a priori* probability used as a reliability**
   3 **indicator characterizes the soft output variant of this algorithm. This algorithm's maximum likelihood condition is replaced by a maximum *a posteriori* condition in the BCJR algorithm. This algorithm repeatedly adds branch metrics to a stored branch metric, compares them, and selects the largest one,**
   6 **making it equivalent to finding the (*)** shortest path through a trellis. For 10 points, name this algorithm used to decode convolutional codes.
   ANSWER: **Viterbi** algorithm [or: **BCJR** algorithm until "a priori" is read]– F4C

3. **For silicon substrates, self-assembled monolayers based on octa-decyl-trichloro-silane, ODTS, and per-fluoro-decyl-trichloro-silane, FDTS, have been used to negate this phenomenon. An innovative method**
   3 **for avoiding this phenomenon involves displacing an etchant with water, which is then displaced with methanol, which is then displaced by liquid CO_2 in a pressure chamber, where the liquid CO_2 is transformed to its supercritical phase and then to gaseous CO_2. In working devices, this phenomenon**
   6 **commonly appears as a result of electrostatic forces or acceleration due to shock. This phenomenon can be negated by etching dimples into a sacrificial layer, so that the final structure also has dimples, which limits its contact area with the substrate. This phenomenon commonly occurs due to (*)** capillary
   9 forces after the sacrificial layer in a surface-micromachined structure is wet etched. For 10 points, name this major mode of failure for MEMS devices that occurs when the MEMS structure adheres to the substrate.
   ANSWER: **stiction** [prompt on: **Van der Waals** forces, **electrostatic** forces, **capillary** forces, **hydrogen bridging**] – F5C

4. **A type of this circuit that avoids the time delay of its simplest implementation feeds a "catching" diode, D_2, and a resistor, R_2, from the minus pin of an op-amp, with D_2's cathode connected to the**
   3 **anode of diode D_1 in the output stage and R_2 being connected to D_1's cathode, v_{out}. The activation of the simplest example of this circuit only requires the input voltage to exceed the diode voltage drop divided by the open-loop gain, making it ideal for use with very (*)** tiny voltages. That simplest example
   6 consists of a diode connected between the output pin and minus pin of an op-amp, providing negative feedback. The v_{out} v. v_{in} plot for that example shows v_{out} as 0 for negative v_{in} and equal to v_{in} thereafter. For 10 points, name this circuit synonymous with a half-wave precision rectifier and which has a cool name.
   ANSWER: **superdiode** [until it is read: half-wave **precision rectifier**; prompt on: half-wave **rectifier**] – F4T

5. Due to this operating system being written in PL/1, or Programming Language One, it became one of the first operating systems to be written in a high-level language. This operating system unified its virtual address space with the file system such that each segment in the virtual address space was addressable by a file; that scheme allowed all information it controlled to be addressed directly by the processor and made it possible to control access to all information in the system. It was created for the GE-645 mainframe. A Robert Daley and Jack Dennis paper that is a classic in operating system design is titled *Virtual Memory, Processes, and Sharing in [this operating system]*. It is commonly cited as an example of the second-system effect, compared to it's predecessor, (*) CTSS. This enormously influential time-sharing operating system was created at MIT. For 10 points, name this operating system that influenced the direction of Unix, whose name is a pun on it.
ANSWER: **MULTICS** [or: **Multiplexed Information and Computing Service**] – F4O

6. A feedback filter, fed by the detector, is subtracted from a feedforward filter, fed the input signal, to reduce the incidence of this phenomenon in the decision-feedback equalizer. In the presence of this phenomenon, the optimal detector is the maximum-likelihood sequence detector, though it's unwieldy at increasing sequence lengths. This phenomenon decreases the noise margin and increases the sensitivity to timing error because it distorts the zero crossings on an eye pattern, causing the eye to narrow. This phenomenon is eliminated if the Fourier transform of a transmitted signal satisfies the relation X of f plus m divided by the sampling period equals the sampling period for $-\infty < m < +\infty$; that relation satisfies the Nyquist criterion for having zero of this phenomenon. The incidence of this phenomenon is commonly reduced by eschewing square pulses for pulses with a (*) raised cosine spectrum. For 10 points, name this phenomenon in which subsequent symbols are distorted by the Doppler spreading and "smearing" of previously transmitted symbols.
ANSWER: **intersymbol interference** [or: **ISI**] – F4C

7. Light-induced degradation of this material creates dangling bonds and can be reversed by annealing, a result first brought to light by D.L. Staebler and C.R. Wronski. This material suffers from a naturally high defect density that is suppressed by "hydrogenating" it. Because one can easily manufacture this material to have a bandgap between 1.7 to 2.2 eV, it pairs well with lower bandgap materials in tandem solar cells, including a very similar material with short-range (*) order: micro-crystalline silicon. For 10 points, name this non-crystalline form of silicon.
ANSWER: hydrogenated **amorphous silicon** [or: **a-Si**:H; do not accept: "silicon"] – F5C

8. The biggest drawback of these filters is that their group delay has a huge peak compared to other IIR filters. The transfer function for these filters has a denominator of the form one plus epsilon squared times the square of T-sub-N of big Omega, where T-sub-N is defined as the cosine of N times inverse cosine of Omega, for absolute value of Omega less than one, and hyperbolic cosine of N times inverse hyperbolic cosine of Omega for absolute value of Omega greater than one. These filters only have poles, which lie in an ellipse in the complex plane. The even or oddness of their order determines whether unity or the reciprocal of one plus epsilon squared is where their (*) oscillations start. These filters achieve a fast roll-off by allowing equiripples in the passband – though, if said passband ripple is set to 0%, a maximally flat filter named for Butterworth is achieved. For 10 points, identify these filters that get their name from the Russian mathematician's polynomials used in their derivation.
ANSWER: type I **Chebyshev** filter [or other transliterations of "Chebyshev": **Tschebyscheff**, **Tchebysheff**, **Tchebichef**, **Tchevysheff**] – E3C

9. **According to Kasap's *Optoelectronics and Photonics: Principles and Practices* and precious few other sources, the equation used to calculate the multiplication factor for an avalanche photodiode is named**
3   **for one guy with this surname. Another guy with this surname developed a theorem, widely used to create high-frequency equivalent circuits, that basically allows one to replace an impedance Z branch between voltages V_1 and V_2 with an equivalent impedance branch from each of V_1 and V_2 to**
6   **ground. In multistage amplifiers, pole splitting is induced and stability increased in a type of frequency compensation named for that guy with this surname if a (*)** capacitor is placed across the input to output of the high-gain stage(s). For an amplifier with a voltage gain of $-A$ and an impedance connected input to
9   output, an effect discovered by that guy gives the input impedance for a resistor or inductor as a factor of $1+A$ smaller. For 10 points, give this surname attached to said effect, which also causes a feedback capacitor in the voltage gain stage of an amplifier to appear a factor of $1+A$ larger.
    ANSWER: **Miller** [or: John Milton **Miller**] – E4O

10. **The manufacturer of this material includes an application note for 3D carbon microfabrication, where the very amusing graphic of this material being pyrolyzed has a Paint-esque overlay of spiky orange,**
3   **signifying flame, a subtle underlay of smooth gray, signifying smoke, and a light source in the center signifying the ignition source. Instead of using HMDS, it's common to use the proprietary OmniCoat™ as an adhesion promoter for this material. The softbake and post-exposure bake for this material**
6   **normally requires two hot plates, as it is done in two steps: one at 65 Celsius, the other at 95 Celsius. It is notorious for being near-impossible to remove once hardbaked. The gamma butyro-lactone solvent used for its original formulation was replaced by cyclopentanone for its 2000 series. This (*)**
9   Microchem-peddled resist has an aspect ratio greater than 10:1 and can be up to 100 microns thick, making it ideal for MEMS applications. For 10 points, name this epoxy-based negative photoresist.
    ANSWER: Microchem **SU-8** 2000 – F5C

11. **When designing a filter to which this transform is applied, one does not use the frequency of interest, f, instead using the frequency given by the equation $\frac{f_s}{\pi} \times \tan\left(\frac{\pi f}{f_s}\right)$. That equation yields significant**
3   **deviations in frequency for frequencies close to the Nyquist frequency and is used for pre-warping. This transform is an alternative to the impulse invariant method of designing filters and preserves filter order. Matlab's c2d with the method `tustin` is an implementation of this transform. This**
6   **conformal mapping takes a (*)** continuous-time transfer function, $H(s)$, and substitutes $s = \frac{2}{T}\left(\frac{z-1}{z+1}\right)$ to obtain $H(z)$, a discrete-time transfer function. For 10 points, name this method used to transform an analog filter into an equivalent IIR filter.
    ANSWER: **bilinear** transform [until "`tustin`" is read: **Tustin**'s method] – F5T

12. **This item lends itself to using the method of constant Q lines. For RF and microwave frequency circuits, measuring the s-parameters instead of the two-port H-, Y-, and Z-parameters allows one to use them**
3   **with this item, specifically s_{11} & s_{22}, but not s_{12} or s_{21}. These items are often used in conjunction with a slotted line in order to expand the number of parameters that can be determined. Generating this item requires a bilinear Möbius transform from the complex Z plane to the complex Γ plane. The**
6   **principal application of this item is to facilitate the determination and elimination of a load mismatch. This item only exists in the domain of the (*)** reflection coefficient. The left and right origins of this item are 0 and ∞, respectively, while its center is 1 because you normalize by the characteristic impedance. Its
9   upper and lower halves are inductive and capacitive, respectively. For 10 points, name these circular diagrams heavily used in transmission line theory.
    ANSWER: **Smith chart** – E3O

13. **The examples of this process with the lowest threshold energy – as required by momentum and energy conservation – are denoted 1 & 7, though the CHCC process is also of great importance. This parasitic**
    3   **process in LEDs has a rate dependence proportional to the cube of carrier concentration, so it's a major process in highly-doped structures. Depth profiling with a spectroscopy based on this process, generally used for smaller areas than (*)** XPS, typically uses an inert argon gas beam to strip away
    6   surface layers; that type of spectroscopy is used to obtain compositional information about the surface of a semiconductor. This process is basically the reverse of impact ionization. For 10 points, name this process in which the energy from a recombining electron and hole is transferred to another electron or hole instead of
    9   being emitted as a photon.
    ANSWER: **Auger** recombination [in place of "recombination": "effect", "process", obvious equivalents; until "impact ionization" is read: **impact** recombination] – D3C

14. **For the final project of my neural networks class, I was supposed to use this neural network to forecast El Niño events. Park and Sandberg extended Cybenko's universal approximation theorem for a**
    3   **separate neural network to this neural network, when it has the same smoothing factor in each kernel. The centers of the first layer in this neural network are usually adjusted via k-means clustering, and popular training methods for it are orthogonal least squares or gradient descent. The input to this**
    6   **feedforward neural network is fed without weighting to a number of locally-tuned units in a nonlinear hidden layer whose outputs are fed as a weighted linear combination to the output nodes. A number of good choices present themselves for its activation function, including the: thin-plate spline, multi-**
    9   **quadratic / inverse multi-quadratic function, and Gaussian function. Unlike the conceptually-similar multi-layer (*)** perceptron-with-backpropagation, this neural network separates classes with hyperspheres. For 10 points, name this neural network whose namesake functions depend only on the distance from the
    12 origin and originated in the field of interpolation.
    ANSWER: **RBF** neural network [or: **radial basis** function neural network] – E4C

15. **Blue LEDs are commonly surrounded with a cerium-doped matrix of this material, as they together form a phosphor that shifts part of the blue spectrum towards a broad yellow, giving the appearance**
    3   **of white light emission. Most nonplanar ring oscillators use this crystal as a host material. A device using this crystal has some problems when used at its (*)** 946 nanometer transition because it's only a
        three-level gain medium. This crystal is best known for its use as a diode-pumped solid-state laser, emitting at
    6   1064 nanometers when doped with neodymium. For 10 points, identify this pervasive garnet.
    ANSWER: **YAG** [or: **yttrium aluminum** garnet] – D4C

16. **When using this technique, one sometimes has to correct for the distance between the depletion edge and where the Fermi level intersects the energy level of interest, which is known as the lambda effect.**
    3   **Weighting functions for this technique include the high-resolution GS4 and the boxcar, which is a pair of positive and negative unit rectangular pulses; such weighting functions multiply this technique's measurements and the result is integrated over time to obtain a spectrum. The activation energy for**
    6   **the things investigated in this technique can be determined by plotting emission rate over temperature squared v. 100 over temperature on an Arrhenius plot. The delay times t_1 and t_2 for this technique determine the rate window and the temperature of the maximum peak shifts. This technique applies**
    9   **a reverse bias pulse to a Schottky diode or p-n junction and measures the (*)** transient capacitance due
        to the thermal emission of majority carriers from trap levels as the junction bias returns to steady-state. For
        10 points, name this highly sensitive technique for characterizing defects in semiconductors.
    ANSWER: **DLTS** [or: **deep-level transient** spectroscopy] – F5T

17. **This type of wafer is the main substrate for an etching solution that's five parts pure HF, two parts CrO$_3$, and one part H$_2$O, which is named for Erhard Sirtl. Anisotropically etching this type of wafer,**
3 **for example with KOH or TMAH, takes an insane amount of time, but is wont to create straight walls rather than the 54.74 degree walls created by a similar type of wafer. Unlike other orientations, the Young's modulus, Poisson's ratio, and shear modulus for this type of wafer are vertically *and***
6 **transversely isotropic. Those etching and mechanical properties of this type of wafer make it an ideal substrate for bulk-micromachined MEMS. For diameters of less than 6 inches (150 millimeters), these wafers can be identified by either a secondary flat at a 45 degree angle from the primary or lack of**
9 **a secondary flat altogether. Instead of cleaving at 90 degree angles, this type of wafer cleaves at 60 degree angles, forming triangular pieces. For 10 points, name this (*)** second most commonly used silicon wafer after (100) silicon.
   ANSWER: (**111**) silicon wafer [prompt on: **silicon** wafer; do not accept: other Miller indices] – F4C

18. **This effect's most successful application has been in DFB lasers, where it may allow a negative chirp factor. This effect breaks inversion symmetry, so parity selection rules no longer apply and interband**
3 **transitions with odd Δn are allowed. This effect underlies self-electro-optic effect devices, or SEEDs. Both the Franz-Keldysh effect and this effect must be considered for electro-absorption modulators based on large structures. This effect reduces the energy of bound states in a quantum well under the**
6 **influence of an applied electric field, which modulates the effective bandgap, and forces a particularly large decrease in the exciton binding energy. For 10 points, name this effect in which an electric field applied in the growth direction of a quantum well produces a (*)** shift in energy level and which is
9 named for a classical analog.
   ANSWER: **QCSE** [or: **quantum-confined Stark effect**] – F5O

19. **This procedure can be accomplished with a bolted blank flange or bolted slip blind, since using bolt cutters or other metal-cutting tools apparently counts as "excessive force" or "unusual techniques".**
3 **A common implementation of this procedure uses a 6– or 12–hole hasp. This procedure is typically *not* used in transmission and distribution programs. A typical part used in this system is diagonally-candy-cane-striped and features "DANGER" in white text, sitting inside of a white-outlined red oval,**
6 **itself sitting inside a black rectangle. Said hasps require an (*)** "energy isolating device" in order to be effective. For 10 points, identify this system, named for its two components, which ensures that dangerous machines and hazardous devices remain off while being serviced.
   ANSWER: **lockout/tagout** [or: **LOTO**, **lock** and **tag**, **switch**ing and **tag**ging] – N/A

20. **Alan Oppenheim's introduction of the complex cepstrum reduced the complexity of using this method, which is a generalization of cepstral analysis, aka quefrency analysis. This method applies to nonlinear**
3 **systems that obey a principle of superposition under an operation other than addition because such systems can be transformed to a summed system that can be linearly filtered. Thus, this method is notably used to remove (*)** multiplicative noise. In image processing, this method specifically refers to
6 applying a high-pass filter to the Fourier transform of the sum of the natural log of the illumination and natural log of the reflectance. As reflectance varies quickly while illumination does not, this method normalizes brightness and enhances contrast. For 10 points, identify this "filtering" technique named for the fact that it
9 uses a structure-preserving map.
   ANSWER: **homomorphic** filtering [in place of "filtering": "convolution", "processing"; do not accept: "homomorphism"] – E4T