

Show your work.

Name _____

Fill in the blanks, circle the correct answers, etc.

1. (149) Quickies

a) An electric heater with a resistance of 70Ω will use _____ joules of energy in 3 minutes when plugged into a 120 V, 60 Hz source.

b) It takes _____ W of electrical power to operate a three-phase, 30 HP motor that has an efficiency of 83% and a power factor of .76.

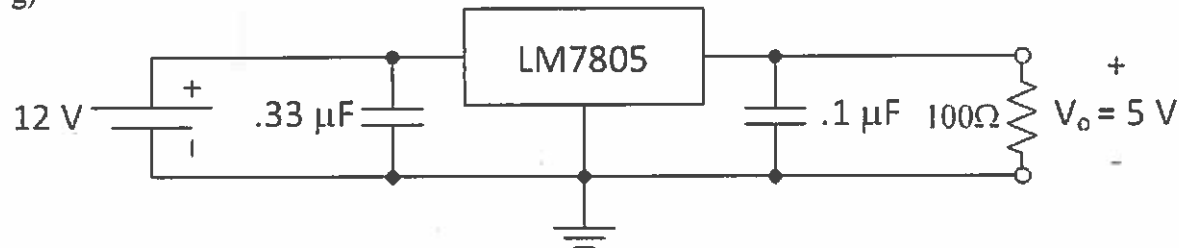
c) A 3.6 V Li-ion battery has a rated capacity of 3500 mAh. It can be expected to last _____ hours if it is connected to a device that has a resistance of 50Ω .

d) Failure of what organ of the body is the most frequent cause of death in electrical accidents?

e) An electrical receptacle has three wires: black, white, and green. Which one of these is most dangerous to touch? _____

f) What electrical device is used in wet locations and outdoors to protect people from shock?

g)



What kind of device is the LM7805? _____

h) An induction motor with a synchronous speed of 3600 rpm operates with a slip of 3% under full load. What is the speed of the motor? _____. How many poles does this motor have? _____

i) What type of memory technology is used as the primary memory of most desktop PCs?

j) What type of memory technology is used in "thumb drives" (USB drives)? _____

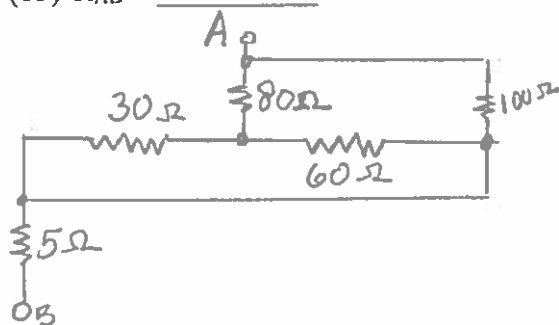
k) An A/D converter has an analog input of $2 + 2.95 \cos(45t)$ V. Pick appropriate values for V_{ref+} and V_{ref-} for the A/D converter. $V_{ref+} =$ _____. $V_{ref-} =$ _____

- l) An analog input to an A/D converter contains frequencies varying from 250 Hz to 3500 Hz. The minimum sampling frequency of the A/D converter should be _____ samples/second.
- m) The voltage across a (an) _____ cannot be changed instantaneously.
- n) The output of an 8-bit A/D converter is equivalent to 105 in decimal. Its output in binary is _____.
- o) Sketch and label a D flip-flop.
- p) A 200 HP motor operating at full load rotates at 887 RPM. Its torque is _____ Nm
- q) An audio amplifier should have a (high, moderate, low) input impedance and a (high, moderate, low) output impedance.
- r) Which one of these cable types should NOT be used to connect a sensor to a differential amplifier? coaxial cable, unshielded cable, twisted pair, shielded cable, shielded twisted pair
- s) A(n) _____ buffer can have three outputs: logic 0, logic 1, and high impedance.
- t) A “100 Ω ” resistor has a tolerance of 5%. Its actual minimum resistance is _____ Ω .
- u) A $\frac{4}{\Lambda}$ H inductor carries a current of $5 + 3e^{-2t}$ A. Its voltage is _____ V.
- v) Which one of the following is NOT associated with inductance? flash lamp, motor, relay, solenoid, transformer
- w) A charge of 10 μ coulombs is stored on a 5 μ F capacitor. The voltage on the capacitor is _____ V.
- x) A manufacturing plant pays a bill to the electrical utility each month based on the maximum power that they use. This is called a(n) _____ charge.
- y) If the line-to-line voltage in a three-phase power distribution system is 12,470 V, the line-to-neutral (line-to-ground) voltage is _____ V.
- z) In a _____ three-phase system, all the voltages have the same magnitude and all the currents have the same magnitude.
- aa) For RC filters, the half-power point is also called the _____ dB point.
- bb) 0111 1010 in binary is _____ in decimal.
- cc) Level 1 _____ memory is inserted between the microprocessor and main memory to reduce the effects of the “memory wall.”
- dd) _____ allows (for example) a microprocessor to fetch one instruction while decoding another instruction and while executing yet another instruction.

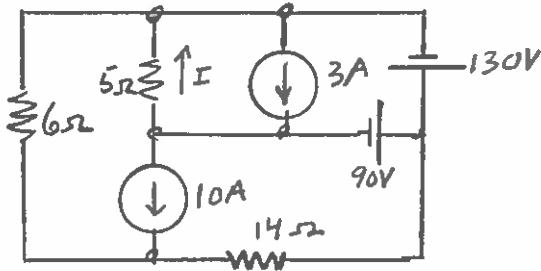
- ee) _____ Law predicts that processing power will double approximately every 18 months.
- ff) Two amplifiers are connected in series. The first has a gain of 3 and the second has a gain of 4. If a 5 mV signal is present at the input of the first amplifier, the output of the second amplifier will be _____ mV.
- gg) A certain operational amplifier has V^- of -12 V. The V^+ voltage should be _____ V.
- hh) A differential amplifier is good at reducing _____ mode noise.
- ii) Laptops, cell phones, and tablets usually have rechargeable _____ batteries.
- jj) A(n) _____-diode leaks current in the reverse direction in the presence of light.
- kk) Most induction motors have a _____ cage rotor.
- ll) Commutators and _____ on universal motors tend to wear out.
- mm) An induction motor operates at 1146 rpm at full load. Its unloaded speed will be approximately _____ rpm.
- nn) Which type of wiring is most common in residences? BX, conduit, Romex
- oo) Sketch and label an NPN bipolar junction transistor.
- pp) Sketch and label the torque-speed curve of an induction motor.

qq) A low pass filter has a cutoff frequency of 100 Hz. What is its gain in dB at 450 Hz? _____ dB

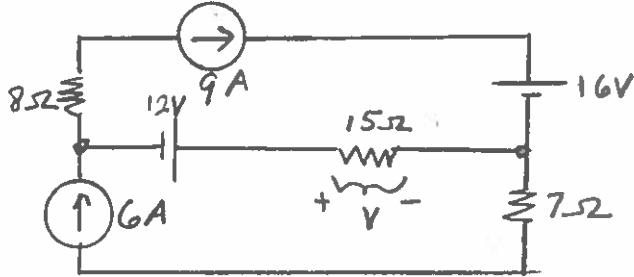
2. (15) $R_{AB} = \underline{\hspace{2cm}}$. The answer is an integer.



3. (15) $I = \underline{\hspace{2cm}}$. The answer is an integer.

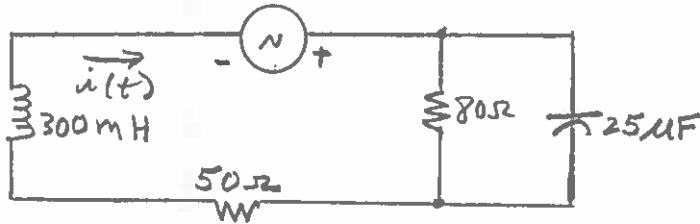


4. (15) $V = \underline{\hspace{2cm}}$. The answer is an integer.



5. (40) Find the steady-state value of $i(t)$. Use phasors. Include a diagram of the transformed circuit.

$$170 \cos(377t + 12^\circ) \text{ V}$$



6. (25) Design, sketch, and label an op-amp circuit that has an input voltage of $+0.4\text{ V}$ and an output voltage of -8 V . You have an ideal op-amp and the following resistors: $4.8\text{ k}\Omega$, $5\text{ k}\Omega$, $20\text{ k}\Omega$, $55\text{ k}\Omega$, $75\text{ k}\Omega$, $100\text{ k}\Omega$, $150\text{ k}\Omega$. Carefully analyze your circuit to prove that it has the required output.

7. (30) A device is known to contain only DC sources and resistors. It has two wires sticking out of it. If a 50 V battery is connected to the two wires, a current of 20 A flows into the positive end of the battery. If a 110 V battery is connected in place of the 50 V battery, a current of 10 A flows out of the positive end of the battery. How much current will flow in an $8\ \Omega$ resistor connected in place of the battery? The answer is an integer.

8. (30) The following three loads are connected to a 120 V, 60 Hz line: A 10 kW motor with a lagging power factor of .815, a 12 KVA air conditioner with a leading power factor of .92, and a 5 KVAR capacitor. Calculate the current in the line feeding the three loads.

9. (16) A three-phase, delta-connected load consumes 25 kW at a power factor of .77 lagging. The line voltage is 460 V, 60 Hz. Find a) the phase voltage of the load, b) the line current, c) the phase current of the load, and d) the power consumed by one phase of the load.

10. (21) $i(t) = 50 \cos(800t + 74^\circ)$ A

$i(0) =$ _____ A

$i(.005) =$ _____ A

$I_{\max} =$ _____ A

$I_{\min} =$ _____ A

$I_{\text{rms}} =$ _____ A

Phasor $I =$ _____ A

$\omega =$ _____ radians/s

$f =$ _____ Hz

$T =$ _____ s

11. (15) Design, sketch, and label a hi-pass filter with a cutoff frequency of 800 Hz. Use a $0.03 \mu\text{F}$ capacitor and an appropriate resistor.

12. (15) For each of the applications below, select the most appropriate motor type from the following list: Brushless DC, single-phase induction, three-phase induction, permanent magnet, series (universal), shunt, stepper, single-phase synchronous, three-phase synchronous, variable reluctance.

Kitchen blender: _____

Tiny toy car: _____

Motor with an electronic commutator: _____

Industrial motor operating at exactly 1200 rpm: _____

Residential forced-air fan: _____

Most common industrial motor: _____

Ink-jet head positioning: _____

13. (10) Sketch and label a parallel resonant circuit with these components: $20 \text{ k}\Omega$ resistor, $3 \mu\text{F}$ capacitor, 4 H inductor. The resonant frequency of this circuit is _____ Hz. The impedance at resonance is _____ Ω .

14. (10) Sketch and label a transformer with a primary voltage of 120 V, a secondary voltage of 6 V, and a load of 3Ω . The current in the primary is _____ A.

15. (10) A sensor can be modeled by its Thevenin equivalent circuit: A $3 \mu\text{V}$ source in series with a $500 \text{ k}\Omega$ resistor. This sensor is connected to an amplifier with an input impedance of $1 \text{ M}\Omega$ and a gain of 20,000. The output voltage of the amplifier is _____ V.

16. (20) a) Sketch and label a half-wave rectifier with capacitor smoothing. Use a $15 \sin \omega t \text{ V}$ source, an ideal diode, a $10 \mu\text{F}$ capacitor, and a $1.2 \text{ k}\Omega$ load. b) Sketch the voltage across the load. Include numeric values for voltage on your sketch.

17. (15) A circuit consists of 3 red LEDs (forward voltage = 2.0 V, peak reverse voltage = 5.0 V, steady current = 20 mA, max current = 180 mA), a 200Ω resistor, and a $14 \cos \omega t \text{ V}$ source, all in series. a) Sketch and label the circuit. b) The peak current in the circuit is _____ mA.

18. (8) A three-phase induction motor is connected to a 480 V line. It draws 75 A of line current. The motor is 93% efficient and has a lagging power factor of 77%. This motor consumes _____ kW of power.

BONUS (+5 points) When making multiple measurements (n) from a source contaminated by noise, you will average the n measurements and the accuracy of your result will be proportional to

_____.