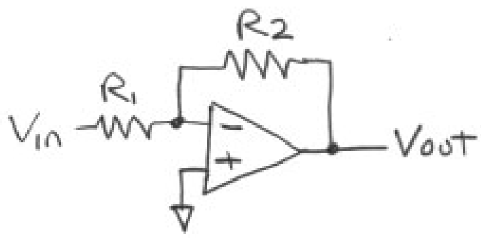
BioE 1310 - Exam 2 3/29/2011
Answer Sheet - Correct answer is A for all questions

1. If $R_2 = 30\text{K}\Omega$, $R_1 = 10\text{K}\Omega$, $V_{in} = 1\text{V}$, which of the following is (are) true?



I - $V_{out} = -3V$.
II - The negative input of the Op Amp will be at 0 volts.
III - The magnitude of the current through R_1 is the same as through R_2.

A. I, II, and III

B. I and II

C. I

D. II and III

E. I and III

Explanation: $V_{out} = -V_{in}\frac{R_2}{R_1}$. The same current will run through R_2 as R_1. The inputs to the op amp will be equal, i.e., at ground.
[*circuits0185.mcq*]

2. A circuit takes sinusoidal input signal with amplitude $V_{in} = 10\mu\text{V}$ and produces an output sinusoidal signal of the same frequency with amplitude $V_{out} = 1\text{mV}$. The gain of the system is

A. 40 dB

B. -20 dB

C. 20 dB

D. -40 dB

E. 0 dB

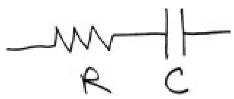
Explanation: Since we are talking amplitude, $20log_{10}(\frac{10^{-3}}{10^{-5}}) = 40$.
[*circuits0210.mcq*]

3. Evaluate the complex number expressed in polar notation by $\frac{1}{2\angle 45°}$

A. $\frac{1}{2\sqrt{2}} - \frac{1}{2\sqrt{2}}j$
B. $\frac{1}{2\sqrt{2}} + \frac{1}{2\sqrt{2}}j$
C. $\frac{2}{\sqrt{2}} + \frac{2}{\sqrt{2}}j$
D. $\frac{2}{\sqrt{2}} - \frac{2}{\sqrt{2}}j$
E. None of the other answers is correct.

Explanation: The angle in the denominator becomes negative.
[*circuits0211.mcq*]

4. What is the total complex impedance (in ohms) of this branch if $C = 0.1\mu$F, $R = 20$KΩ, f = 100KHz?



A. $2 \times 10^4 - 1.59 \times 10j$
B. $2 \times 10^4 + 1.59 \times 10j$
C. $2 \times 10^4 - 10^2 j$
D. $2 \times 10^4 + 10^5 j$
E. $2 \times 10^4 - 1.59 \times 10^4 j$

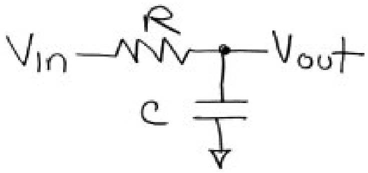
Explanation: The impedance of a capacitor is $1/j\omega C$, $\omega = 2\pi f$. The unit of complex impedance is still ohms.
[*circuits0212.mcq*]

5. Euler's Identity $e^{j\theta} = \cos\theta + i\sin\theta$, can be rewritten as $\cos\theta = \frac{e^{j\theta}+e^{-j\theta}}{2}$ and $\sin\theta = \frac{e^{j\theta}-e^{-j\theta}}{2j}$.
Using these, which of the following is an equivalent expression for $\cos^2\theta$?

A. $\frac{1+\cos 2\theta}{2}$
B. $\frac{1+\sin 2\theta}{2}$
C. $\frac{1-\cos 2\theta}{2}$
D. $\frac{1-\sin 2\theta}{2}$
E. $\sin^2\theta$

Explanation: Simply square $\cos\theta = \frac{e^{j\theta}+e^{-j\theta}}{2}$ and regroup terms.
[*circuits0041.mcq*]

6. Which of the following is true about the circuit below?



A. If V_{in} is a sinusoid at a particular frequency $\omega = \frac{1}{RC}$, the magnitude of the impedances of the resistor and the capacitors are equal

B. The circuit is a high pass filter.

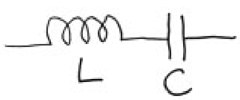
C. The circuit is not a linear system.

D. DC passes through the capacitor as if it were a piece of wire.

E. At different frequencies of V_{in} the phase of V_{out} does not change, only its magnitude.

Explanation: It is a low pass filter, and is a linear system since resistors and capacitors are linear. The capacitor does not pass DC (the voltage would climb forever). Both phase and the voltage of V_{out} changes with frequency. Substituting $\omega = \frac{1}{RC}$ into the impedance of a capacitor, $\frac{1}{j\omega C}$, yields $|R| = |\frac{1}{j\omega C}|$, so the correct answer, A.
[*circuits0213.mcq*]

7. The following are true about the circuit below *except*



A. This is a high-pass filter.

B. The circuit resonates at a particular frequency.

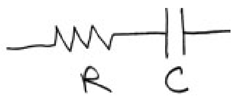
C. At frequency $\omega = \frac{1}{\sqrt{LC}}$ the impedance is 0.

D. At very low frequencies it approaches infinite impedance.

E. At very high frequencies it approaches infinite impedance.

Explanation: At very high frequencies the coil approaches infinite impedance and at very low frequencies the capacitor does likewise. This is a bandpass filter (letting a certain frequency through at $\omega = \frac{1}{\sqrt{LC}}$, not a high-pass filter.
[*circuits0214.mcq*]

8. The total complex impedance of this branch is



A. $\frac{1+j\omega RC}{j\omega C}$

B. $\frac{1+RC}{j\omega C}$

C. $1 + j\omega RC$

D. $R + j\omega C$

E. None of the other answers are correct.

Explanation: The total impedance is that of the capacitor, $\frac{1}{j\omega C}$, plus that of the resistor, R. Combining terms yields a reassuring RC term in the numerator.
[*circuits0183.mcq*]

9. The following are true about bipolar transistors *except*

A. The base current I_B can pass in either direction.

B. The bipolar transistor we use in lab has three terminals, the Emitter, Base, and Collector.

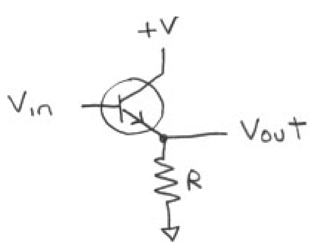
C. When properly biased, the collector current I_C and the base current I_B are related by an approximately constant proportion, β.

D. They come in two varieties, NPN and PNP, depending on the arrangement of regions with either extra electrons or extra "holes".

E. When properly forward-biased, they exhibit a voltage drop between the base and emitter, similar to that of a diode, of about 0.5-0.7 volt.

Explanation: The base current I_B can only pass in one direction, from the Base to the Emitter (in an NPN transistor), since the Base-Emitter junction behaves as a diode.
[*circuits0215.mcq*]

10. If $+V = 5\text{V}$, $R = 1\text{K}\Omega$, $V_{in} = 2\text{V}$, $\beta = 150$, and the base-emitter voltage drop is 0.5V, what would you expect the current through R to be?



A. 1.5 mA

B. 2 mA

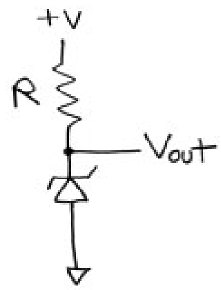
C. 300 mA

D. 225 mA

E. None of the other answers is correct.

Explanation: Current $= \frac{V_{in}-0.5\text{V}}{R}$; β is not needed.
[*circuits0216.mcq*]

11. Which of the following is *false* about the circuit below, given that $R = 1\text{K}\Omega$, $+V = 10\text{V}$, and the zener diode has a reverse breakdown voltage of 4V.



A. Current flows through the zener diode in a direction opposite to the voltage across it.

B. The voltage $V_{out} = 4V$.

C. The current through the resistor is 6mA.

D. The zener diode is back biased.

E. The zener diode is used because, as opposed to most diodes, the reverse breakdown voltage is intentionally low at some known voltage.

Explanation: Current through a passive device cannot flow opposite to the voltage across it, or you would have an infinite source of energy.
[*circuits0217.mcq*]

12. The following are true about thermistors *except*

A. Unlike standard resistors, the impedance of a thermistor is non-linear.

B. Like a standard resistor, a thermistor generates heat when a current is passed through it in the amount of I^2R.

C. A thermistor can be manufactured to have either a positive or a negative temperature coefficient.

D. Like a standard resistor, the resistance of the thermistor constitutes a real (non-imaginary) impedance.

E. Whereas most resistors show some variation in resistance with temperature, a thermistor demonstrates an intentional variation that is generally larger than that of an ordinary resistor.

Explanation: Thermistors change resistance intentionally with temperature. The one we used in the lab had a negative temperature coefficient. All resistors heat up when a current is passed through them, including thermistors, though that is not the purpose of a thermistor. The impedance of a thermistor is still real, it just varies. Like a standard resistor, the impedance is linear.
[*circuits0218.mcq*]

13. Which of the following is *false* about the light sensor used in our lab.

A. It is a photovoltaic device that generates a voltage from light (a small "solar cell").

B. It is constructed of cadmium-sulfide.

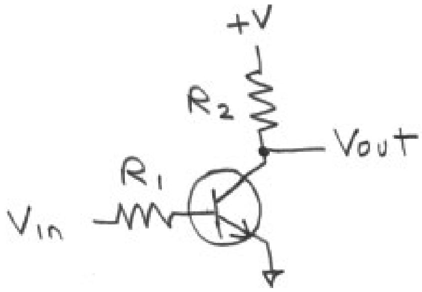
C. It passes current in both directions equally.

D. Its resistance goes from very high in total darkness to much lower in bright light.

E. It is fairly slow and insensitive compared to other types of light sensors, but robust and easy to use.

Explanation: Solar cells are photodiodes, whereas this is a photoresistor.
[*circuits0219.mcq*]

14. If $R_1 = 100\ K\Omega$, $R_2 = 2$ KΩ, $V_{in} = 2.5$ V, $+V = 10$ V, with a $\beta = 100$ for the transistor, and a base-emitter voltage drop of 0.5 V, what voltage would you expect at V_{out}?



A. 6 V

B. 5 V

C. 8 V

D. 7 V

E. 4 V

Explanation: The Voltage across R_1 is 2 V $-$ 0.5 V, so the base current is 2V/100 $K\Omega = 20\ \mu$A. Collector current is thus 20 μA $\times$ 100 = 2 mA. Voltage across R_2 = 2 mA $\times$ 2 KΩ = 4V. V_{out} = 10 V $-$ 4 V = 6 V
[*circuits0220.mcq*]

15. Kirchoff's current law states that for any given node in a circuit

A. the sum of the currents entering the node equals the sum of the currents leaving the node.

B. the voltage with respect to ground is what is meant when no other reference point is specified.

C. when a current enters a node, electric charge accumulates without appreciable effect.

D. the voltages around a loop add to zero.

E. current times voltage equals resistance.

Explanation: Because electrons are, in effect, non-compressible, they cannot build up at any given node appreciably, and all of the current entering the node must also leave it. Answer B is correct, but not Kirchoff's current law. Answer D is correct but is Kirchoff's *voltage* law.
[*circuits0081.mcq*]

16. Regarding energy in electronic circuits, which of the following is *false* (or all are true)?

A. All are true.

B. Energy is stored in a capacitor in the charge difference between the plates, as described by the equation $E = \frac{1}{2}CV^2$, and may be retrieved by discharging the capacitor.

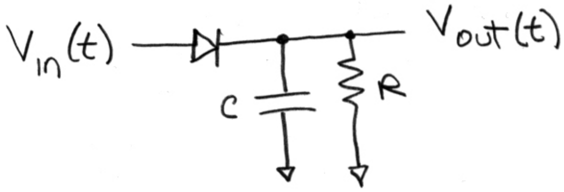
C. Energy is stored in a inductor in the magnetic field created by the current, as described by the equation $E = \frac{1}{2}LI^2$, and may be retrieved by harnessing the current to do work.

D. The energy stored in a battery is commonly stated in units of "ampere-hours", but the voltage of the battery must also be known to convert this into joules.

E. Power (Energy/Time) in the form of heat is produced in a given resistor as described by the equation $P = I^2R$, and may not be efficiently retrieved as electrical power.

Explanation: I kid you not.
[*circuits0150.mcq*]

17. The following are true about the circuit below *except* (or all are true).



A. All are true.

B. The circuit is known as a "peak detector".

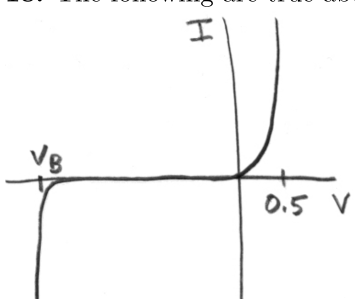
C. When the diode is forward biased, $V_{out}(t)$ will follow the peak voltage in $V_{in}(t)$, minus the approximately 0.5V drop across the diode.

D. The capacitor acts as the voltage "memory".

E. The resistor provides a way for the capacitor to eventually discharge.

Explanation: To a first approximation, $V_{out}(t)$ will follow the peak voltage in $V_{in}(t)$, although approximately 0.5 V below it. The resistor provides a way to discharge the capacitor and thereby limit the time period over which the peak is remembered by the voltage on the capacitor.
[*circuits0221.mcq*]

18. The following are true about the the graph below *except* (or all are true).



A. When the component is back-biased, the current is in the opposite direction from the voltage.

B. It represents the current as a function of voltage for a diode.

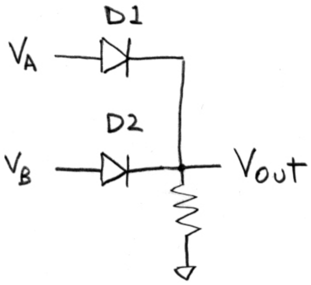
C. The forward-biased voltage asymptotes to approximately 0.5 V.

D. When reversed-biased, the component demonstrates practically zero current up to a "breakdown voltage" at which it gives way.

E. All are true.

Explanation: When the component is back-biased (or forward-biased), the current is in the same direction as the voltage. This is always true for a passive component; otherwise it would be generating energy on its own.
[*circuits0222.mcq*]

19. The following are true about the the circuit below *except* (or all are true).



A. With actual diodes, V_{out} will always be a little bit ($\sim$ 0.5V) below *both* V_A and V_B.

B. If either V_A or V_B is high (e.g. near 5V), V_{out} is also high.

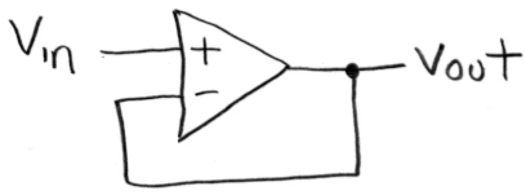
C. If V_A is at 5V and V_B is at ground, D1 will be forward-biased and D2 will be back-biased.

D. This represents a logical OR gate.

E. All are true.

Explanation: With actual diodes, V_{out} will always be a little bit ($\sim$ 0.5V) below *the higher of* V_A and V_B.
[*circuits0223.mcq*]

20. The following are true about the the circuit below *except* (or all are true).



A. It is an example of positive feedback.

B. This is commonly called a "buffer".

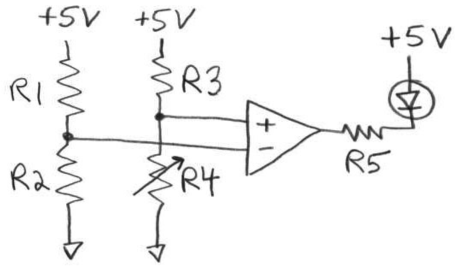
C. It puts practically no load on input voltage V_{in}.

D. It produces an output voltage V_{out} that is practically identical to the voltage seen at V_{in}.

E. All are true.

Explanation: This is example of *negative* rather than *positive* feedback.
[*circuits0224.mcq*]

21. What value must variable resistor R_4 be adjusted to for the comparator to be just at the point of turning the LED on, or off, in the following circuit, if $R_1 = 100\ \Omega$, $R_2 = 300\ \Omega$, $R_3 = 600\ \Omega$, and $R_5 = 200\ \Omega$?



A. 1800 Ω

B. 200 Ω

C. 300 Ω

D. 400 Ω

E. 600 Ω

Explanation: The voltages at the (+) and (−) inputs of the comparator are equal when $\frac{R_1}{R_2} = \frac{R_3}{R_4}$
[*circuits0225.mcq*]

22. Which of the following are properties of the ideal operation amplifier?

I - Infinite input impedance.
II - Zero output impedance.
III - Infinite gain.

A. I, II, and III

B. I and II

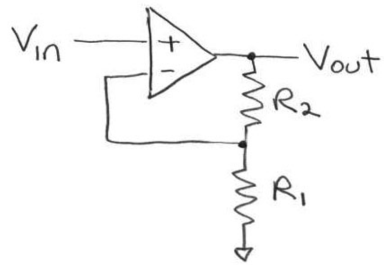
C. II and III

D. I and III

E. Only III

Explanation: All are true.
[*circuits0226.mcq*]

23. If $R_1 = 100\Omega$, $R_2 = 200\Omega$, and $V_{in} = 2$V, the following are true *except* (or all are true)?



A. $V_{out} = 3$V.

B. If the op amp is considered to be ideal, V_{out} will not change, no matter how much current a load may draw from the output of the circuit.

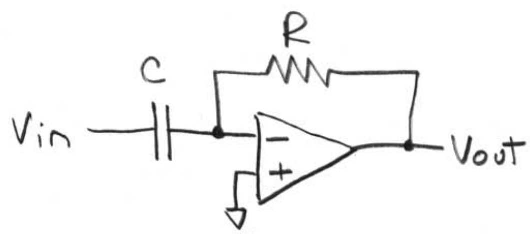
C. This is a non-inverting amplifier circuit.

D. The circuit puts virtually no load on V_{in}.

E. All are true

Explanation: $V_{out} = \frac{R_1+R_2}{R_1} V_{in}$. so $V_{out} = 6$V.
[*circuits0227.mcq*]

24. Given the following circuit, the following statements are true *except* (or all are true)



A. Given a DC input at V_{in} the voltage on the capacitor will continue to increase at a constant rate forever (or until it reaches the positive power supply).

B. It is a differentiator.

C. It employs a virtual ground.

D. The current through the capacitor is proportional to the derivative of the input voltage, and that current passes through the resistor as well (because it cannot go into the op amp).

E. All are true.

Explanation: This is a differentiator. The negative input is a virtual ground. Answer A describes the voltage on a capacitor in the integrator configuration, not the differentiator.
[*circuits0228.mcq*]

25. The following are true about comparators and operational amplifiers, *except*

A. Op amps are generally modeled to have infinite gain, whereas comparators are not.

B. They both can generally be modeled to have infinite input impedance.

C. Comparators tend to be used to determine which input is higher, and often have positive feedback (hysteresis) added to prevent chatter when the inputs are very close in value.

D. Op amps circuits tend to be designed with negative feedback, in which an implicit equation is solved by having the output do what it must to keep the inputs equal.

E. Op amps tend to be used with dual (+ and −) power supplies, whereas comparators are often used with a single (+) power supply.

Explanation: Both operational amplifiers and comparators are modeled to have infinite gain. The fact that an comparator can accurately compare, means that it must have very high gain so that the two compared voltages can be very close.
[*circuits0110.mcq*]