CMPSCI 145 MIDTERM #1 Solution Key

SPRING 2017

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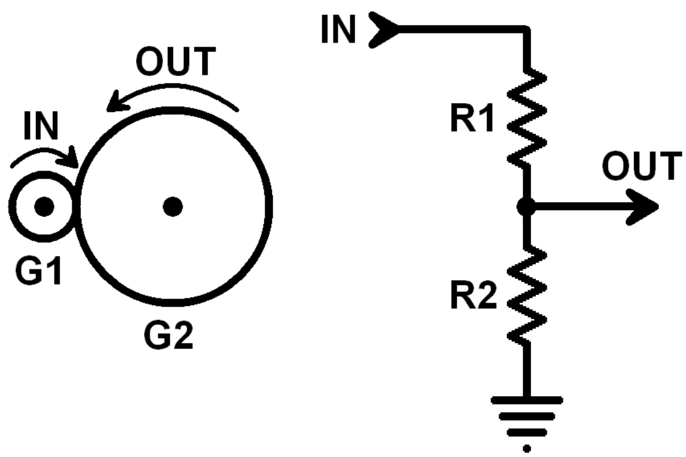
NAME	

PROBLEM	SCORE	POINTS
1		10
2		10
3		15
4		15
5		20
6		12
7		8
8		10
TOTAL		100

<1> 10 Points – Examine the following diagram of two systems, one involving gears and the other involving resistors. Resistor **R1** is 2000 Ohms, and resistor **R2** is 1000 Ohms. Gear **G1** has 50 teeth.



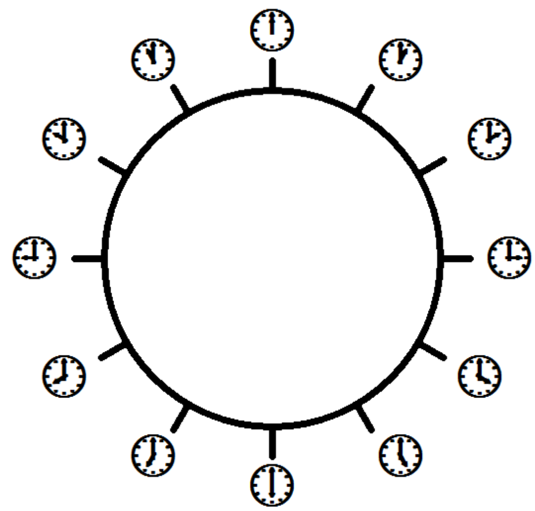
A. (5 points) What is the output voltage of the circuit if the input voltage was 24 volts?

The total resistance is 3000 Ohms, and the output voltage is measure across the 1000 Ohm resistor, so the output voltage is ⅓ of the input. If the input is 24 volts, the output is then **8 volts.**

B. (5 points) How many teeth must gear **G2** have so that the division ratio of the gears matches the division ratio of the resistors? (Ignoring differences in sign.)

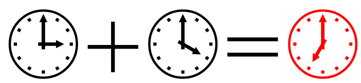
G2 must spin at ⅓ the rate of G1, so it must have 3 times the number of teeth as G1. Thus, G2 must have **150 teeth.**

<2> 10 Points – The image to the right shows a standard 12-hour clock, where the 12:00 position represents zero.



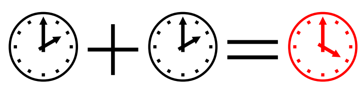
Compute the following sums, and tell me if there is an unsigned overflow, a signed overflow, both or neither:

5 points:



3+4=7, which does not give an unsigned overflow, but in "signed clock" 3+4=-5, which is a **signed overflow**.

5 points:



2+2=4, which is **neither** a signed nor an unsigned overflow.

Scoring: 5 points each problem, 3 for the answer (-1 for not expressing the answer as a clock) and 2 for the correct determination of overflow.

<3> 15 Points (1 point each box) – Solve each sum below, and then tell me, ***yes or no***, if it exhibits ***unsigned overflow*** or ***signed overflow***. For problems that use ***four-digit decimal*** arithmetic (base 10), the left-most digit is the sign digit, and you are to write down only the right-most four digits of the sum even if a carry to a fifth digit is generated. For problems that use ***eight-bit binary*** arithmetic (base 2), the left-most bit is the sign bit, and you are to write down only the right-most eight bits of the sum, even if a carry to a ninth bit is generated. (-½ per problem for writing extra digits.)

Problem	**Sum (in four decimal digits or eight binary bits)**	**Unsigned Overflow?**	**Signed Overflow?**
Decimal: 2409 + 2427	**4836**	**no**	**no**
Decimal: 8723 + 3146	**1869**	**yes**	**no**
Decimal: 7791 + 6918	**4709**	**yes**	**yes**
Binary: 10010111 + 11001011	**01100010**	**yes**	**yes**
Binary: 11010011 + 01011010	**00101101**	**yes**	**no**

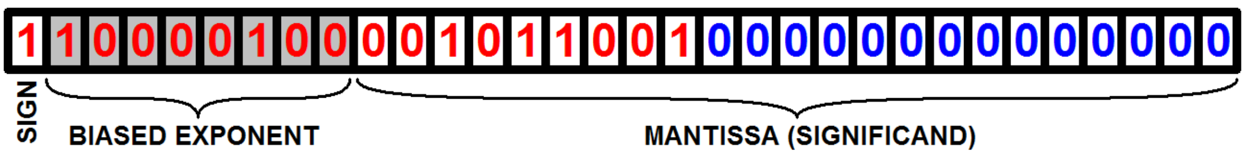
<4> 15 Points (1 point each box) – Show the ***decimal*** (base 10) value of the eight-bit binary numbers interpreted in each of the following ways. ~~One problem has been done for you.~~ For signed interpretations, the left-most bit is the sign bit.

The Number	**01101110**	**11111111**	**10110111**
Unsigned Binary	**110**	**255**	**183**
Sign & Magnitude Signed Binary	**+110**	**-127**	**-55**
One's Complement Signed Binary	**+110**	**-0**	**-72**
Two's Complement Signed Binary	**+110**	**-1**	**-73**
Unsigned Fixed-Point (6 bits whole number, 2 bits fraction)	**27.5**	**63.75**	**45.75**

Note for scoring: the signed values all have + or – as prefixes. The + prefix is recommended, but not required.

<5> 20 Points – Convert the decimal number **-37.5625** into True Binary (5 points), Binary Scientific Notation (5 points), and Single-Precision Floating Point (10 points). Show your work for partial credit.

True Binary:	**-100101.1001** (sign 1 point, integer 2 points, fraction 2 points)
Binary Scientific:	**-1.001011001** $\times 2^5$ (sign 1 point, mantissa 2 points, exponent 2 points)



(1 point) The number is negative, so sign bit = 1.

(3 points) The true exponent is 5, so after adding the bias of 127 the biased exponent is 132, or 10000100 in binary, which is stored in the biased exponent field.

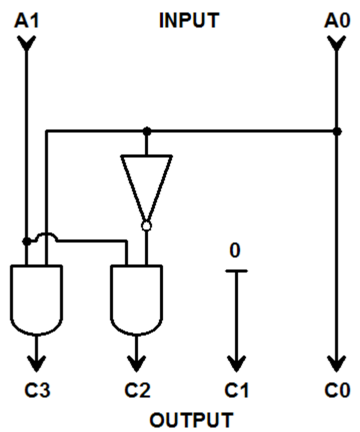
The significant digits are 1.001011001, so after suppressing the leading 1 the fraction that is actually stored is 001011001 (4 points, -1 for keeping the leading 1-bit) and the remaining bits are padded with 0 bits (2 points).

Note for scoring: if the True Binary is wrong but all subsequent derivations are consistent with that wrong answer, there should be no additional penalty. Similarly, if the True Binary is right and the Binary Scientific is wrong, there will be no additional penalty if the Single Precision is correctly derived from the incorrect Binary Scientific.

<6> 12 Points – Which of the following devices are analog and which are digital? (2 points each)

A. A slide rule **Analog**
B. Magnetic core memory **Digital**
C. A gear **Analog**
D. A NAND-gate **Digital**
E. A hydraulic press **Analog**
F. A resistor-capacitor circuit **Analog**

<7> 8 Points – Trace the following circuit and show the outputs for all given inputs. (½ point each.)



A1	A0	C3	C2	C1	C0
0	0	0	0	0	0
0	1	0	0	0	1
1	0	0	1	0	0
1	1	1	0	0	1

Note that this circuit squares its input.

<8> 10 Points – SHORT ANSWER – How is dividing a decimal number by 10 similar to dividing a binary number by 2? (For example, 5247 ÷ 10 = 524.7 and 110101 ÷ 2 = 11010.1) Consider the concept of "shifting" in your answer. Use the back of this page for your answer.

Dividing a decimal number by 10 shifts the number to the right, and the least significant integer digit goes to the right of the decimal point. Similarly, dividing a binary number by 2 also shifts the number one bit to the right, and the least significant bit goes to the right of the decimal point (actually, binary point).

To generalize, dividing any number in any base by an integer N is the same as right-shifting the number in base N, and the base N remainder goes to the right of the decimal point. This allows conversion of any number in any base to any other base. (For example, dividing a decimal number by 2 using base 10 arithmetic effectively shifts the number right by one bit in binary, allowing for easy conversion of decimal to binary.)

Scoring: Assign the full 10 points if the answer is a reasonably complete discussion of shifting AND talks about using the method for base conversion (that is, they "get it"), assign 5 points for any intermediate answer, and 0 points if the answer is completely bogus.