CMPSCI 145 MIDTERM #1

Solution Key

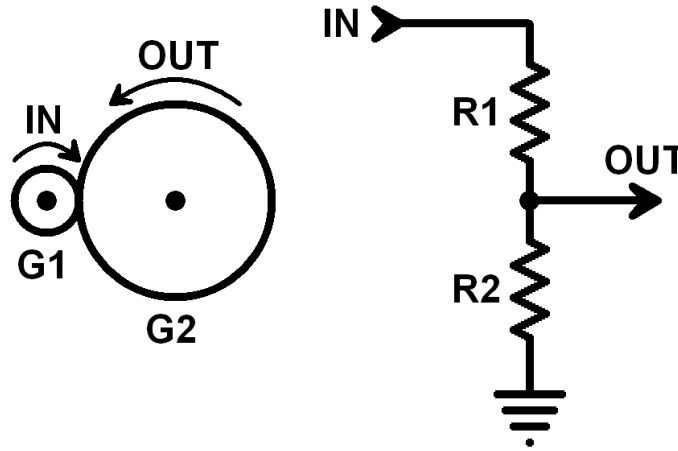## SPRING 2018

March 2, 2018

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<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 4000 Ohms. Gear **G1** has 50 teeth.

A.   (5 points) What is the output voltage of the circuit if the input voltage was 24 volts? $24 \times (4000 / (2000 + 4000)) = 24 \times \frac{2}{3} =$ **16 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.)
          50 is to 2 as what is to 3? This leads to $3 \times 50 / 2 =$ **75 teeth**

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

A. Indicate on the diagram where +1 and -1 are located in a signed interpretation.

See red +1 and -1 on diagram. 1 point each.

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

Use the blue numbers to understand the signed aspects of this problem.   The unsigned values are the face values of each of the small clocks from 0 (12) up to 11.

2 points each for the answer in "base clock"

2 points each for the overflow answer.
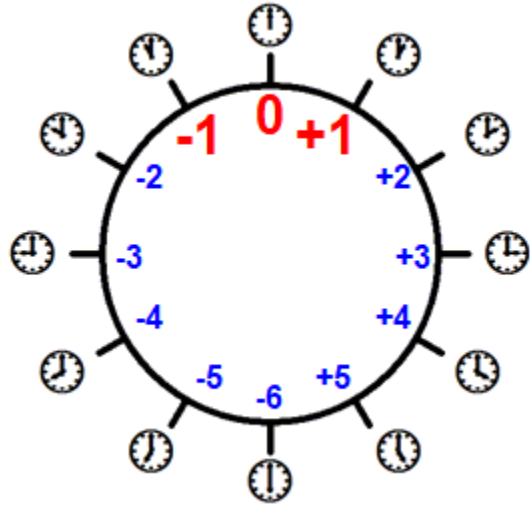
🕒 + 🕖 = 🕙 neither   (unsigned: $3 + 7 = 10$,
                       signed: $+3 + -5 = -2$)

🕑 + 🕒 = 🕔 neither   (unsigned: $2 + 3 = 5$,
                       signed $+2 + +3 = +5$)

<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 <u>four</u> 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 <u>eight</u> bits of the sum, even if a carry to a ninth bit is generated.

| Problem	Sum (in <u>four</u> decimal digits or <u>eight</u> binary bits)	Unsigned Overflow?	Signed Overflow?
Decimal: 3719 + 1192	4911	NO	NO
Decimal: 3824 + 9216	3040	YES	NO
Decimal: 8391 + 7818	6209	YES	NO
Binary: 01110101 + 01111011	11110000	NO	YES
Binary: 11110011 + 00011010	00001101	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	01111001	10000000	10100101
Unsigned Binary	121	128	165
Sign & Magnitude Signed Binary	+121	−0	−37
One's Complement Signed Binary	+121	−127	−90
Two's Complement Signed Binary	+121	−128	−91
BCD (if illegal answer ERROR)	79	80	ERROR

<5>　10 Points – In the following image of a slide rule, the top slider is set to 2.1 on the bottom bar.

3 points. Show where the answer will be for solving the multiplication 2.1 × 2.1 on the bottom bar.
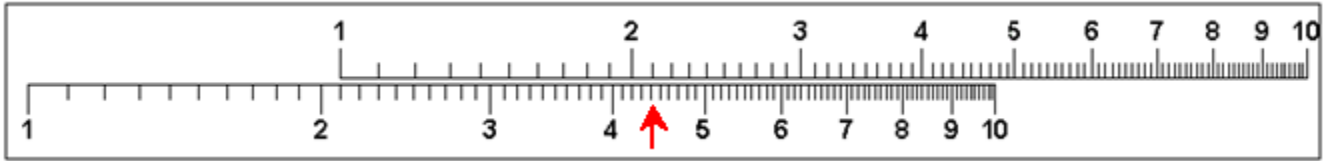
2 points. Does that answer fall exactly on one of the tic marks on the bottom bar?　**NO**

3 points. How many digits of precision is this device?　**2**

2 points. Is that enough precision for the 2.1 × 2.1 problem?　**NO**

NOTE: 2.1 × 2.1 = 4.41 exactly (3 digits of precision), but the closest mark on the slide rule is 4.4 (2 digits of precision)

<6>　14 Points (2 points each) – Which of the following devices are analog and which are digital?

A.	A mechanical cam to compute logarithms	**Analog**
B.	Magnetic core memory	**Digital**
C.	A gear	**Analog**
D.	A NOR-gate	**Digital**
E.	A hydraulic press	**Analog**
F.	A flip-flop	**Digital**
G.	A car speedometer using a dial and needle	**Analog**

<7>   16 Points (1 point each box) – Trace the following circuit and show the outputs for all given inputs.

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

A1   INPUT   A0

0

C3   C2   C1   C0
OUTPUT
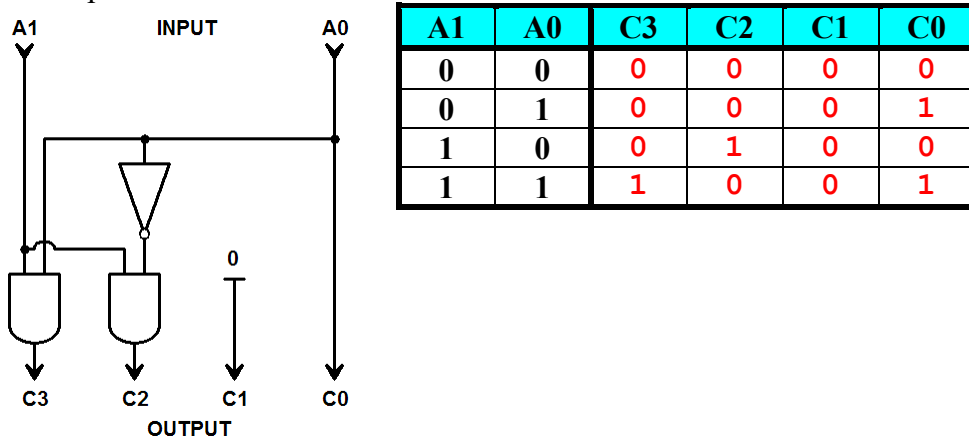
5 Points Extra Credit: What does this circuit compute?

It computes the **square** of its input.

<8>   10 Points – SHORT ANSWER – The Inuit peoples of icy Greenland don't use paper maps, but instead use carved wooden maps as shown below here.   What are the representational trade-offs between the two forms? Why might I use one over the other? Answer on the back of this page.

Paper is lightweight and folds up small, but is **not readily available** in Greenland, and would **degrade quickly** in the wet environment.

The wooden carving is **sturdy**, doesn't readily degrade, and can be **used by a hand in a pocket** (keeping the hand warm). It is a **tactile representation rather than visual**: as long as the edges can be felt, the person can interpret where the peninsulas and inlets are located without having to look at it.

NOTE to grader: you may see a wide variety of answers on this question, including a list of possible representations listed on the first day of class (availability, technology, visualization, robustness, etc.), or you may see a simple "paper not available" answer. Please grade as:
        10 points: they get the bulk of the idea,
        5 points: some ideas are OK but not complete or some bits wrong, and
        0 points: totally wrong.