CMPSCI 145 MIDTERM #1

Solution Key

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CMPSCI 145 – Spring 2020 – In-Class Midterm Exam #1 Solution Key
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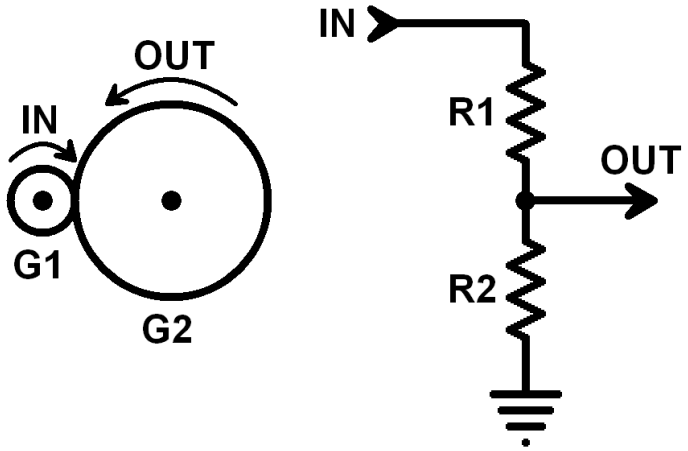
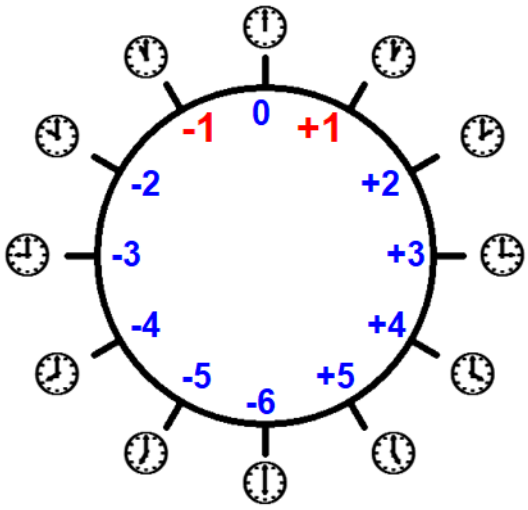
<1> 10 Points – Examine the following diagram of two systems, one involving gears and the other involving resistors. Resistor **R1** is 3000 Ohms, and resistor **R2** is 1500 Ohms. Gear **G1** has 20 teeth.



A. (5 points) What is the output voltage of the circuit if the input voltage was 60 volts? **20 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.)
60 teeth

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



A. (1 point) Indicate on the diagram where +1 and -1 are located in a signed interpretation.
(Required positions shown in red)

B. (3 points each, 1 point for sum, 2 points for the overflow) Compute the following sums, and tell me if there is an unsigned overflow, a signed overflow, both or neither:

 (3+7=10) neither

 (10+7=5, -2+-5=+5) both

 (2+3=5) neither

<3> 18 Points (1 point each box) – Show the ***decimal*** (base 10) value of the four-bit binary numbers interpreted in each of the following ways. For signed interpretations, the left-most bit is the sign bit.

The Number	0101	1111	1010
Unsigned Binary	5	15	10
Sign & Magnitude Signed Binary	+5	-7	-2
One's Complement Signed Binary	+5	-0	-5
Two's Complement Signed Binary	+5	-1	-6
BCD (if illegal answer ERROR)	5	ERROR	ERROR
Excess-3 (if illegal answer ERROR)	2	ERROR	7

<4> 15 Points – A new floating-point system uses 20 bits per number: 1 for the sign bit, 6 for the biased exponent, and 13 for the mantissa.

A. (2 points) What is the ***bias*** value for this format? $2^{6-1}-1 = 2^5-1 = 32-1 =$ **31**
(Accept any of the forms shown above)

B. (3 points) Write into the boxes below the binary value for +infinity?

0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

(1 point each for sign, exponent, and mantissa, remove ½ per section for minor errors)

C. (5 points) Write into the boxes below the binary value for -1.0?

1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

(1 point for sign, 2 for exponent, 2 for mantissa, -½ per minor error)

D. (5 points) Write into the boxes below the binary value for the number that has the binary scientific notation value of $+1.10011011100111010101001 1 \times 2^5$ (round up any bits that don't fit into the mantissa). **Rounded bits shown in blue.**

0	1	0	0	1	0	0	1	0	0	1	1	0	1	1	1	0	1	0	0

(1 point for sign, 2 for exponent, 2 for mantissa, -½ per minor error)

<5> 10 Points – (5 points each) An analog computation system can continuously represent any number between 0 and 10 (inclusive), but no other values. The scale markings are good to one digit to the right of the decimal point (that is, 0.0, 0.1, 0.2, …, 9.9, 10.0).

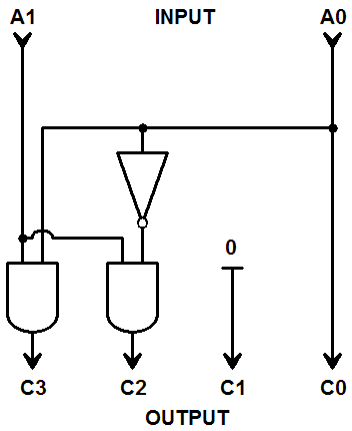
A. What happens when the computation 1.5×2.3 is attempted?
The product, 3.45, **requires more digits of precision** than are marked on the scale, so **the answer will not fall exactly on a scale mark** (but will be **halfway between** 3.4 and 3.5). Score as 5 points (they mostly get it), 3 (some right, some wrong/incomplete), 1 (a little bit there), or 0 (blank or not even close).

B. What happens when the computation 6.9×7.2 is attempted?
Overflow. The product, 49.68, **is larger than the maximum value** of 10 that the device can accommodate. Score as 5 points (they mostly get it), 3 (some right, some wrong/incomplete), 1 (a little bit there), or 0 (blank or not even close).

<6> 10 Points – (2 points each) Which of the following are analog and which are digital?

A.	A watch with a sweep second hand.	**Analog**
B.	A NAND-gate.	**Digital**
C.	A hydraulic press.	**Analog**
D.	A light switch.	**Digital**
E.	An odometer in a car with a moving needle.	**Analog**

<7> 16 Points – (1 point each) 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

5 Points Extra Credit: What function does this circuit perform?

The output is the square of the input.

<8> 11 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 **difficult to obtain** in Greenland, paper is **not very sturdy when wet**, and paper maps **have to be unfolded** in order to be studied.

In contrast, wooden maps are **rugged**, and can be used and **studied by feel** in cold weather without removing them from inside warm mittens. They also provide a **tactile sense of 3D topology** not possible with flat paper.

I don't expect all students to get all of these reasons, and I do expect that some will come up with valid reasons not covered here. As long as they come up with a valid reason *against* paper and a valid reason *for* wood, they should get full credit.

Score as 11 points (they mostly get it), 6 (some right, some wrong or missing), 3 (a little bit there but not much), or 0 (blank or not even close).