CMPSCI 145 MIDTERM #2

SOLUTION KEY

SPRING 2016

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Items in red are students' expected answers or instructions on scoring to the grader.

Items in light blue are my annotations or explanations, and are not required as part of students' answers.

<1> 15 Points – Answer 15 of the following problems (1 point each). Answer more than 15 for extra credit. Incorrect or blank answers will be ignored.

149	What is the decimal value of the 8-bit ***unsigned*** binary number **10010101** ?
-21	What is the decimal value of the 8-bit ***sign and magnitude*** binary number **10010101** ?
-106	What is the decimal value of the 8-bit ***one's complement signed*** binary number **10010101** ?
-107	What is the decimal value of the 8-bit ***two's complement signed*** binary number **10010101** ?
95	What is the decimal value of the 2-digit ***BCD*** binary number **10010101** ?
62	What is the decimal value of the 2-digit ***XS3*** binary number **10010101** ?
101010011	What is the binary sum of **10010101** and **10111110**? (You may need more than 8 bits.)
100000100 *-or-* **104**	What is the BCD binary sum of **10010101** and **00001001**? (You may need more than 8 bits.)
Denormal	In floating-point, what are numbers called where the biased exponent is equal to zero and the mantissa is non-zero?
NaN *-or-* **NotANumber**	In floating-point, what are numbers called where the biased exponent is all 1-bits and the mantissa is non-zero?
Infinity	In floating-point, what is the number called where the biased exponent is all 1-bits and the mantissa is zero?
Kiss at one point	Two spheres, each of radius 100 units, have centers 200 units apart. Do they overlap, kiss at one point, or miss each other?
Overlap	Two spheres, each of radius 100 units, have centers 150 units apart. Do they overlap, kiss at one point, or miss each other?
Lossy	What kind of compression is used when I save a 24-bit **.BMP** file in the **.JPG** format?
Lossless	What kind of compression is used when I save a 256-color (or less) **.BMP** file in the **.GIF** format?
Dithering	What is it called when I reduce the colors in an image and distribute the error (difference in color) to neighboring pixels?
11025×1×2= **22050**	A sound file is recorded at 2 byte/sample, 1 channel, and 11025 samples/second/channel. How many bytes/second are played?
False (1 part in 65536)	Using 1 byte/sample, a sound can be measured to one part in 256. True/False: 2 bytes/sample is good to one part in 512?
5512.5	What is the maximum frequency that can be represented in a sound recorded at 11025 samples/second/channel?
Steganography	What is it called when I hide a data bit in the low-order bit of either a sound sample or the blue channel of a graphics pixel?

<2> 25 Points – We are going to invent a new floating-point format, called "weird-precision" which is exactly ten bits in length. There is a sign bit, four bits for the biased exponent, and five bits for the mantissa, and all rules are the same as single, double, half, and quarter precision.

A. (3 Points) What is the value of the bias for this format?

$2^{4-1}-1 = 2^3-1 = 8-1 = 7$
Accept only 7 for full credit, 1 point for $2^{4-1}-1$, 2 points for 2^3-1 or 8-1.

B. (15 Points) Fill in all the boxes below with 0 and 1 to form the indicated values:

0 1 1 1 1 1 X X X X	Quiet NaN X: accept 0, 1, X.
0 1 1 1 1 0 0 0 0 0	Positive Infinity
0 1 1 1 0 1 1 1 1 1	Largest Normalized Positive Value
0 0 0 0 1 0 0 0 0 0	Smallest Normalized Positive Value
0 0 0 0 0 0 0 0 0 0	0.0

Three points per answer. Score as 2 for up to two bits in error; score as 1 for three to five bits in error, score as 0 for more than five bits in error.

C. (6 Points) What are the binary scientific, true binary, and decimal values of the following weird-precision number?

0 1 0 0 1 1 1 1 0 1	Biased Exp. = 9, Bias = 7, therefore: True Exponent = 2.
1.11101×2^2 (1 point for $x.xxx\times2^x$, 1 point for bits, 1 point for exponent)	Binary Scientific (3 points)
111.101 (1 point for whole, 1 point for fraction, OK if matches BiSci)	True Binary (2 points)
$7\frac{5}{8} = 7.625$ (1 point for whole, 1 point for fraction, accept either form)	Decimal (2 points)

D. (1 Point) Will the true binary number 1.01×2^9 fit into a weird-precision number?
NO. (Bias is 7, so Biased Exponent = 7+9=16, but largest exponent 1110_2=14)

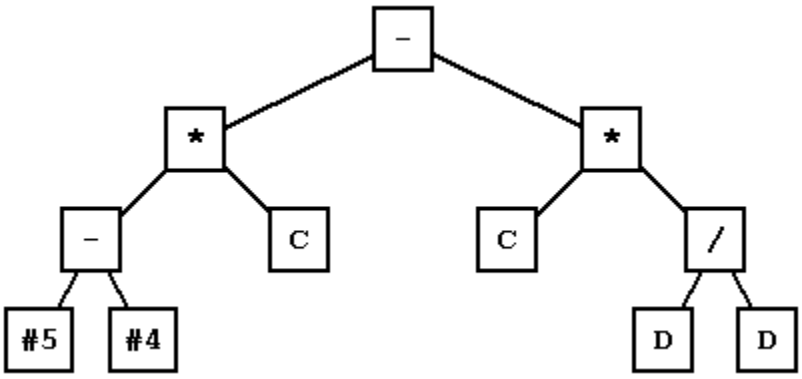
<3> 20 Points – What are the decimal values of the following 32-bit binary number under each of the listed representations? If the value is illegal under the representation, say so.

11000001011000000000000000000000

C1600000	Hexadecimal
Illegal	BCD 1101 is not a BCD digit
$-1.11\times2^3 = -1110 = -14$ *(accept any answer shown)*	Single Precision Floating Point Biased Exponent = $10000010_2 = 130$, True Exponent = 130 – 127(bias) = 3
49504.0	Unsigned Fixed Point, 16 whole and 16 fraction 1100000101100000.0000000000000000

Score each answer as 5 points. For answers with multiple digits, remove 1 point per error.

<4> 10 Points – The image below shows the tree representation for an arithmetic expression (`C` and `D` are algebraic variables, `#4` and `#5` are just the numeric constants 4 and 5, the `*` symbol means multiplication, and `/` means division):



1. (5 points) Write out the complete algebraic equation for the current tree representation ***as shown***, including parentheses where necessary.

   `(5 - 4) * C  -  C * (D / D)`

   Remove 1 point per error. OK to write `5` as `#5`. Extra parentheses OK, as in:

   `((5 - 4) * C) - (C * (D / D))`

2. (5 points) Figure out how to ***optimize*** the tree to most efficiently compute the exact same value as what is shown here, and then draw that resulting tree. (The tree might reduce down to a single node.)

   `#0`

   Score as 5 points, all-or-nothing.

   Optimization steps:

   ```
   5 - 4 = 1,
   1 * C = C,
   D / D = 1,
   C * 1 = C,
   C - C = 0
   ```

<5> 18 Points – There are two 3D points <3,7,-2> and <7,13,-8>. What are the parametric equations in *x*, *y*, and *z* for the straight line that passes through the first point when *t=0* and through the second point when *t=1*?

$x(t) =$ **4** $t +$ **3**

$y(t) =$ **6** $t +$ **7**

$z(t) =$ **-6** $t +$ **-2**

Three points each numerical answer.

In each case the multiplier for *t* is the difference in the coordinate values for the corresponding dimension. The offset is the first of the two values by itself. For example, the multiplier for *x(t)* is the second *x* value minus the first *x* value, or 7 – 3 = 4, and the offset for *x(t)* is just the first *x* value, or 3.

<6> 12 Points – Short Answer – For this problem, consider **.WAV** and **.MP3** sound files, as well as **.BMP** and **.JPG** graphics files, in the light of what we have learned about representations:

How would you interpret the phrase "**.WAV** is to **.MP3** as **.BMP** is to **.JPG**"?
How would you interpret the phrase "**.WAV** is to **.BMP** as **.MP3** is to **.JPG**"?

Statement #1: "**.WAV** is to **.MP3** as **.BMP** is to **.JPG**"

In each pair the first type is uncompressed, while the second type is compressed using a lossy compression technique.

Statement #2: "**.WAV** is to **.BMP** as **.MP3** is to **.JPG**"

The first pair are both uncompressed, while the second pair are both compressed using a lossy compression technique.

I'm looking for some understanding that both **.WAV** and **.BMP** are full-size, ***uncompressed*** files containing all the information for their respective domains (audio or image), while both **.MP3** and **.JPG** are ***compressed***, and that the compression technique used in both cases is ***lossy***. They can interpret the two phrases separately or together.

Scoring: Score as 12 points if students address non-compression, compression, and lossy compression. Score as 6 points if the answer is basically OK but partially incomplete. Score as 0 points if the answer does not address any of these ideas.