• Interm exam 3: Thursday. YOU WILL WRITE CODE to manipulate an image, from scratch. Study all of the image manipulation code you’ve seen so far, and practice writing these methods from scratch.

• PSA6 due tonight, 11:59pm

• Today:
  – Binary numbers
  – Steganography!
Midquarter feedback

• How much are you enjoying CSE8A so far?

A. A lot
B. Some
C. A Little
D. Not at all
Midquarter feedback

• Overall the pace of CSE8A is:

A. Way too fast
B. A little too fast
C. About right
D. A little too slow
E. Way too slow
Midquarter feedback

• How many hours do you spend per week on CSE8A outside of class?

A. < 3
B. 3-6
C. 6-9
D. 9-12
E. > 12
Midquarter feedback

• Overall the work in CSE8A is

A. Way too much
B. A little too much
C. About right
D. Not quite enough
E. Not nearly enough
Midquarter feedback

• How long do you typically wait to get an interview from the tutors?

A. < 30 mins
B. 30-60 mins
C. 1-2 hours
D. More than 2 hours
Midquarter feedback

• How frustrating is your interview experience?

A. Not really at all
B. Only a little
C. Somewhat
D. Pretty
E. Very
Midquarter feedback

• When do you typically get your interview?

A. Before Tuesday
B. Wednesday
C. Thursday
D. Friday
Midquarter feedback

• When would you want to get your interview if you could choose?

A. During a time that is already staffed
B. Wednesday night
C. Thursday morning before 10am
D. Thursday night
E. Other
Midquarter feedback

• Do you do your PSAs with a partner?
  A. Usually yes
  B. About half the time
  C. Usually no
Midquarter feedback

• If you do not work with a partner, why not?

A. Scheduling issues

B. I learn better on my own

C. I don’t want to have to explain what I’m doing to my partner

D. Other
Midquarter feedback

• Do you typically have trouble starting on the PSAs?

A. No, I don’t have any trouble

B. Not really, it takes me a minute to understand, but then I figure it out

C. A little bit, I’m usually a bit confused at the beginning

D. Yes, I usually have no idea where to start
Midquarter feedback

• How often do you attend discussion section?

A. Always (i.e. every week or more than once)
B. Sometimes (every other week or so)
C. Rarely (I’ve been once or twice)
D. Never
1. What is the binary number 100 in decimal?

A. 2
B. 4
C. 8
D. 100
2. What is the decimal number 21 in binary?

A. 10110

B. 10101

C. 11111

D. 00021
3. In the Pixel class we've been working with (and generally in RGB color representation) how many **total** bits (i.e. the total of all the color channels) are used to store a color value.

A. 3

B. 8

C. 16

D. 24
4. What is the approach discussed in the video for hiding information in an image?

A. Replace the last bit (least significant bit) of each color channel with a bit from the secret message.

B. Replace every other Pixel's color with information from the secret message.

C. Sum the secret message with the red color channel in each pixel in the image.

D. Find the average between the information in the hidden message and the value of each color channel.
How can we hide the bunny in the hat?
Cathy saw eight (8) airplanes penetrate skies aloft. 7 really only could keep straight.
Cathy saw eight (8) airplanes penetrate skies aloft. 7 really only could keep straight.
A German press cable from WWI

President's embargo ruling should have immediate notice. Grave situation affecting international law. Statement foreshadows ruin of many neutrals. Yellow journals unifying national excitement immensely.
President's embargo ruling should have immediate notice. Grave situation affecting international law. Statement foreshadows ruin of many neutrals. Yellow journals unifying national excitement immensely.

*Pershing sails from N.Y. June 1.*
And now for an equally bad approach…

Are these two colors the same, or different?
A. The same
B. Different
Hiding information in images

Red | Green | Blue
--- | --- | ---
(39, 56, 101)

Write each of these color values as an 8-bit binary number:

\[
\begin{align*}
\text{Red} & : 00100111 \\
\text{Green} & : 00111000 \\
\text{Blue} & : 01100101
\end{align*}
\]

\[
1 = \overline{00000000}
\]
Hiding information in images

<table>
<thead>
<tr>
<th>Red</th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>56</td>
<td>101</td>
</tr>
</tbody>
</table>

Write each of these color values as an 8-bit binary number

( 00100111, 00111000, 01100101 )
Hiding information in images

<table>
<thead>
<tr>
<th>Red</th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>(39,</td>
<td>56,</td>
<td>101)</td>
</tr>
<tr>
<td>(37,</td>
<td>59,</td>
<td>100)</td>
</tr>
</tbody>
</table>

Will the second color above look the same, or different?
A. Same  B. Different

(00100111, 00111000, 01100101)
What is the maximum amount we can change a value by changing its two least significant digits?

A. 1  B. 2  C. 3  D. 4

(00100111, 00111000, 01100101)
Hiding information in images

Red       Green       Blue
(   39,   56,    101)  
(   37,   59,    100)  

What is the maximum amount we can change a value by changing its two least significant digits?
A. 1  B. 2  C. 3  D. 4
( 00100111, 00111000, 01100101 )
( 00100101, 00111011, 01100100 )

No matter how we change the last two bits, the color will still look the same. (This is probably true for the last 3 bits too...)
What is the maximum amount we can change a value (in decimal) by changing its three least significant digits?

A. 1    B. 3    C. 4    D. 7    E. 8
Hiding information in images

What is the maximum amount we can change a value (in decimal) by changing its three least significant digits?

A. 1  B. 3  C. 4  D. 7  E. 8

( 00100111, 00111000, 01100101 )

( 00100101, 00111011, 01100100 )

Conclusion: We can do whatever we want with the two (and probably three, maybe four?) least significant bits in each color channel without changing the visual appearance of the image. But how does this help us...?
Using 8 bits per color gives us how many possible values for each color channel?

A. 8  
B. 255  
C. 256  
D. $2^8 - 1$

( 00100111, 00111000, 01100101 )
Degraded color information

Using 8 bits per color gives us how many possible values for each color channel?
C. 256 (2^8)

( 00100111, 00111000, 01100101 )

How many different colors does this allow us to represent?
A. 256  B. 256 * 3  C. 256^3

256 choices for red value
256 choices for green
256 choices for blue
Degraded color information

Using 2 bits per color gives us how many possible values for each color channel?
A. 2   B. 3   C. 4   D. 8

( 11, 00, 01 )

00
11
10
01
Degraded color information

Using 2 bits per color gives us how many possible values for each color channel?
C. 4 \( (2^2) \)

( 11 , 00 , 01 )

How many different colors does this allow us to represent?
A. 4  B. 4*3  C. \( 4^3 \)
Degraded color information

Using 2 bits per color gives us how many possible values for each color channel?
C. 4 (2^2)

( 11, 00, 01 )

How many different colors does this allow us to represent?
A. 4  B. 4*3  C. 4^3
2-bit color representation

( 11, 00 , 01 )

What color should this be?

A. Pink(ish)
B. Blue
C. Green
D. White
E. Black
2-bit color representation

( 11, 00 , 01 )

A lot of red

No green

A little blue
2-bit color representation

```
( 11, 00, 01 )
```

What color will this be (in Java)?
A. Pink(ish)
B. Blue
C. Green
D. White
E. Black
Bit shifting

Most significant digit (\(2^7\) place)  Least significant digit (\(2^0\) place)
Bit shifting

What happens to the value of this number (3) if I shift it left one position?

Most significant digit ($2^7$ place)  Least significant digit ($2^0$ place)
Bit shifting

What is the new value of the number (formerly 3)?
A. 6   B. 8   C. 11   D. 12   E. 42

Most significant digit (2^7 place)  Least significant digit (2^0 place)
In general, what happens to a number each time you shift it left? Why?

Most significant digit (2^7 place)    Least significant digit (2^0 place)
In general, what happens to a number each time you shift it left? Why?

Most significant digit ($2^7$ place)  Least significant digit ($2^0$ place)
Bit shifting

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Most significant digit (2^7 place)  Least significant digit (2^0 place)
Bit shifting

In general, what happens to a number each time you shift it left? Why?

Most significant digit (\(2^7\) place)  Least significant digit (\(2^0\) place)
In general, what happens to a number each time you shift it left? Why?

Most significant digit (2^7 place)  
Least significant digit (2^0 place)
Bit shifting

In general, what happens to a number each time you shift it left? Why?

A. Every time you shift left you multiply the number by 2
B. Every time you shift left you square the number
C. Every time you shift left you add 2 to the number
D. Every time you shift left, the number doesn’t change
Bit shifting in Java

>>> 6 << 2

Left shift operator
“Shift the value 6 to the left twice”
Will yield $6 \times 2 \times 2 = 24$
You could write a loop to do the same thing, but why?

```plaintext
0 0 0 0 0 0 1 1 0
```

Most significant digit (2^7 place)

Least significant digit (2^0 place)

```plaintext
>>> 6 << 2
```

Left shift operator

“Shift the value 6 to the left 2 times”

Will yield 6 * 2 * 2 = 24
Bit shifting in Java

Most significant digit (2^7 place)  
Least significant digit (2^0 place)

>>> 6 >> 2

Right shift operator  
“Shift the value 6 to the right 2 times”  
Will yield (6 / 2) / 2 = 1
Hiding information in images

Pixel in context image: (00100111, 00111000, 01100101)

Pixel in secret message (at same x, y position): (01100100, 11111001, 00001111)

SLIGHTLY DIFFERENT ALGORITHM FROM THE VIDEO
Hiding information in images

Pixel in context image: ( 00100111, 00111000, 01100101 )

Pixel in secret message (at same x, y position): ( 01100100, 11111001, 00001111 )

Turn the 8-bit secret message color into a 2-bit color by preserving the two most significant bits. (How? Why?)
Hiding information in images

Pixel in context image ( 00100111, 00111000, 01100101 )

Pixel in secret message (at same x, y position) ( 01, 11, 00 )

Overwrite the two least significant digits in the context image with the 2-bit color of the secret message. (How?)
Hiding information in images

Pixel in context image
(00100101, 00111011, 01100100)

Pixel in secret message
(01, 11, 00)

The secret message is now hidden in the context image! (Make a copy first!)
Recovering information from images

Pixel in context with secret message

( 00100101, 00111011, 01100100 )

Pixel in recovered message (at same x, y position)

( 01, 11, 00 )

Find the two least significant digits from the image with the secret message (How?)

Context image  Secret message
Recovering information from images

Pixel in context with secret message

\[
\begin{align*}
\text{Red} & : (00100101, 00111011, 01100100) \\
\text{Green} & : (00100101, 00111011, 01100100) \\
\text{Blue} & : (00100101, 00111011, 01100100)
\end{align*}
\]

Pixel in recovered message (at same x, y position)

\[
\begin{align*}
\text{Red} & : (01000000, 11000000, 00000000) \\
\text{Green} & : (01000000, 11000000, 00000000) \\
\text{Blue} & : (01000000, 11000000, 00000000)
\end{align*}
\]

Shift the bits in the recovered message to the left. You’ve recovered the message!
Exam 3 practice problem

• Write a method in the Picture class that draws a 10x10 red square in the center of the calling object.

• Do this both by looping over the whole image and using an if statement, and by looping over ONLY the specified region.
Exam 3 practice problem

• Write a method in the Picture class that takes a threshold value for green (an int). It then creates a new Picture and copies into this new Picture only those pixels whose green value is above the threshold. It leaves the rest of the Pixels in the new Pictures blank. It returns the new Picture.
Exam 3 practice problem

• Write a method in the Picture class that takes a target Picture object and copies the calling object’s picture \textit{upside down} onto the target picture. Can you handle the case where the target is smaller than then calling object? How about where the target is larger?
TODO

- Study for Exam 3
- Finish on PSA6
- Feedback on the Piazza form!