**Gamma**

- Basic CRT operation
- Non-linearity of CRT radiance (physical)
- Non-linearity of brightness (percept)
- A happy coincidence!

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**Basic CRT operation**

- Cathode Ray Tube
- Electron gun fires beam of electrons at a phosphor coated screen
- Phosphor glows when hit by electron
- Intensity of glow is a physical property
- Beam is swept side-side top-bottom to draw an image

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**Power Law**

- Intensity varies directly with respect to voltage
  - \( I = V^\gamma \)
  - \( \gamma = 5/2 \)
  - \( \Delta V_0 = \Delta V_1 \)
  - \( \Delta I_0 \neq \Delta I_1 \)
CORRECTION

- To make $\Delta I_0 = \Delta I$.
- adjust $V$ by a power $1/\gamma$
  - $V_{new} = V_{orig}^{1/\gamma}$
  - $I_{new} = V_{new}^\gamma$
  - $I_{new} = (V_{orig}^{1/\gamma})^\gamma$

$\gamma$ Correction

- show gammacorrection.xls
- now can vary intensity in a linear fashion
- precompute $V_{new}$ for each $I_{new}$
- when a desired intensity is to be displayed, look up its required voltage

BRIGHTNESS (PERCEPT)

- brightness: “Attribute of visual sensation according to which an area appears to exhibit more or less light” - CIE
- human visual response to intensity
- NOT LINEAR!
- It’s a Power Law Also!

HUMAN VISUAL RESPONSE

- human ability to discern different levels of light is about 100:1
- anything less than 1% of white level is perceived as black
- within this range we can distinguish between darker shades of gray more easily than between lighter shades
Non-linear response

- A change in intensity at low levels produces a large change in brightness.
- The same change at higher levels produces a smaller change in brightness.

Coding brightness

- Use 8 bits to encode intensity levels = 256 levels.
- Since brightness is non-linear with respect to intensity, if we encode brightness using the same number of levels, we waste codes at high levels (e.g., the eye can’t tell the difference between brightness level 220 and 221).

- A linear coding of brightness will also result in banding/contouring at darker shades of gray.
- To reproduce images, we can’t use a device that uses equal intervals for brightness. It must reflect the non-linear visual response to intensity.

Model brightness as a power function of intensity:

\[ b = i^\alpha \]
Notice that CRT’s non-linearity is “inverse” of eye’s non-linearity?

- using $V$ to represent $B$ makes good sense

<table>
<thead>
<tr>
<th>Percept</th>
<th>Physical</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loudness</td>
<td>SPL</td>
<td>0.67</td>
</tr>
<tr>
<td>Smell</td>
<td>Concentration</td>
<td>0.6</td>
</tr>
<tr>
<td>Brightness</td>
<td>Intensity</td>
<td>0.3-0.45</td>
</tr>
</tbody>
</table>