

### Graphics Display Hardware

- Display technologies
  - CRT, LCD, etc.
- Drawing methods
  - Vector (random), raster
- Control circuitry
  - Scan generation, color, buffering

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### Video Display

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### Cathode Ray Tube (CRT)

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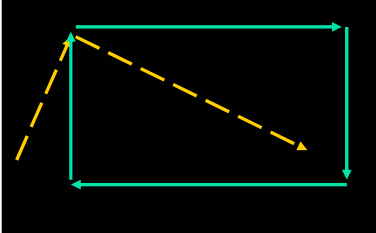
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### Vector (Random) Scanning



A diagram illustrating vector scanning on a black background. A cyan rectangle is shown with a dashed yellow arrow starting from the top-left corner and moving in a random path across the rectangle. The number 4 is in the bottom right corner.

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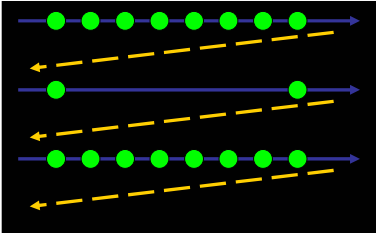
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### Raster Scanning



A diagram illustrating raster scanning on a black background. Three horizontal blue lines with arrows pointing right represent scan lines. Green dots are placed along these lines. Dashed yellow arrows show the path of the electron beam, moving horizontally across each line and then jumping to the start of the next line below. The number 5 is in the bottom right corner.

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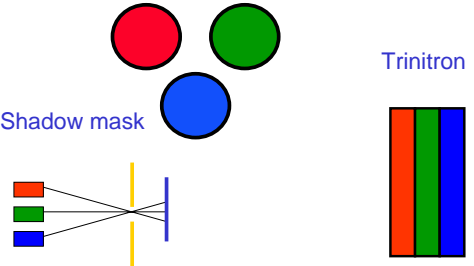
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### CRT Color Display



A diagram illustrating the components of a CRT color display. It shows three colored circles (red, green, blue) labeled "Shadow mask". To the right, the word "Trinitron" is written above a vertical bar with three colored segments (red, green, blue). Below, a diagram shows three colored rectangles (red, green, blue) with lines converging to a point, representing the electron gun and deflection system. The number 6 is in the bottom right corner.

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### Liquid Crystal Displays

- Controlled polarization
  - Voltage determines effect
  - Transmits or reflects light
- Drive mechanisms
  - Active - transistor per pixel
  - Passive - multiplexed
  - Speed, contrast differences

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### Raster Scan System Design

- Frame buffer memory
  - Part of main memory (DMA)
  - Isolated (blanking interval access?)
  - Dual-port
- Video controller
  - Scan generator
  - Video shift register(s)

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### Video Display Timing Example

1024



768

$1024 * 768 = 786,432$  pixels

What about interlace?

768 lines (+ blanking)  
= 900 lines (approx.)

If refresh rate = 70 Hz,  
63K lines/s,  
15.9  $\mu$ s/line.

1024 pixels (+ blanking)  
= 1300 (approx.)

Pixel time = 12 ns,  
dot clock = 82 MHz?

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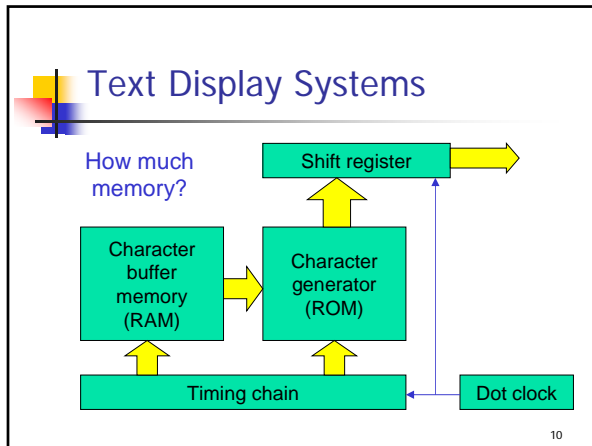
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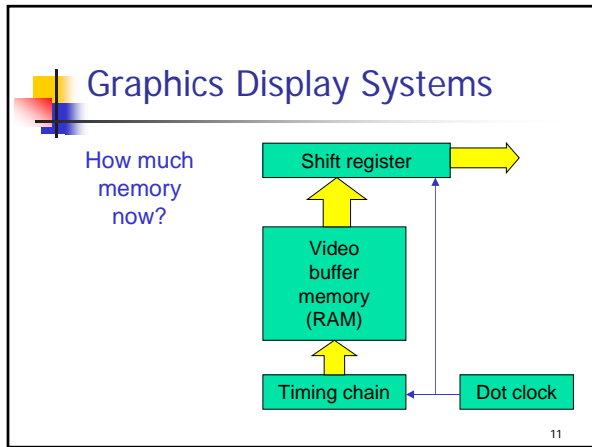
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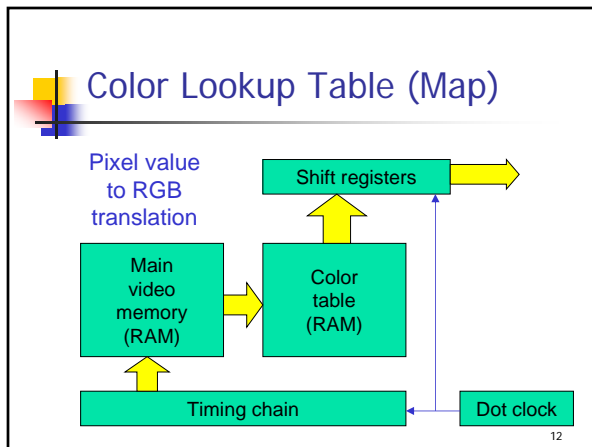
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## Video DAC

- Digital-to-analog converter
  - Gray-scale: one DAC
  - RGB: three DACs
- Converts binary to voltage
  - Must be fast
- With shift reg., color table?
  - RAMDAC

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## Design Exercise

- Simple CRT display
  - Vertical frequency: 60 Hz
  - Active scan lines: 240 (of 256)
  - Active pixels/line: 384 (of 512)
  - Colors: 16 of 512 possible
- Design circuitry

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