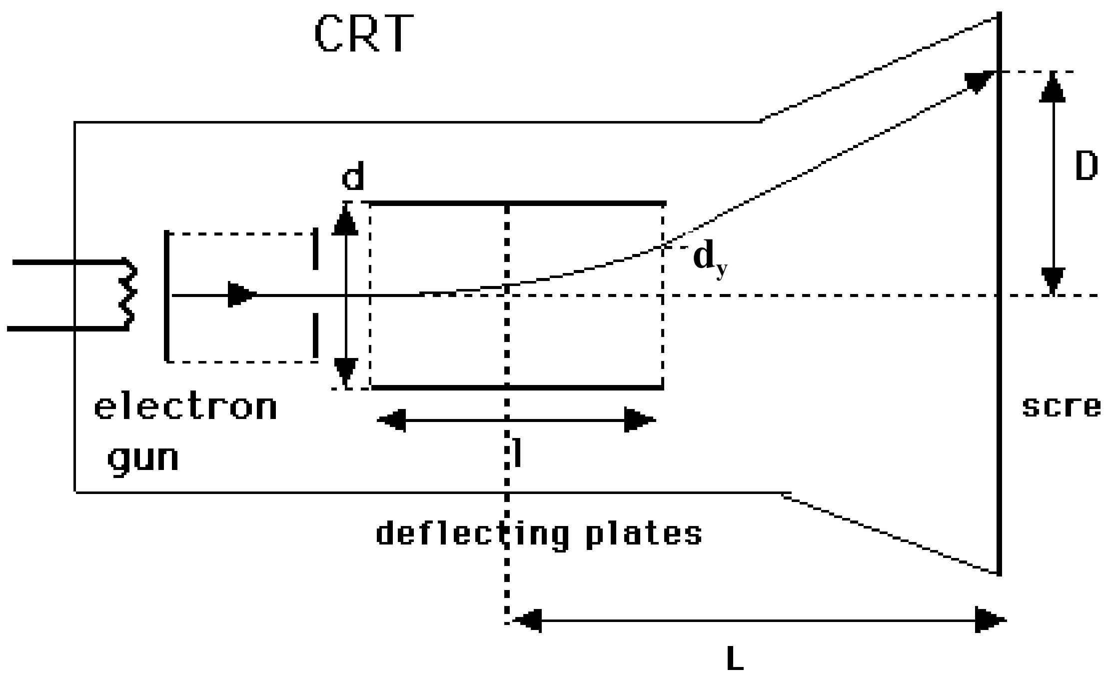
The Cathode Ray Tube (CRT)

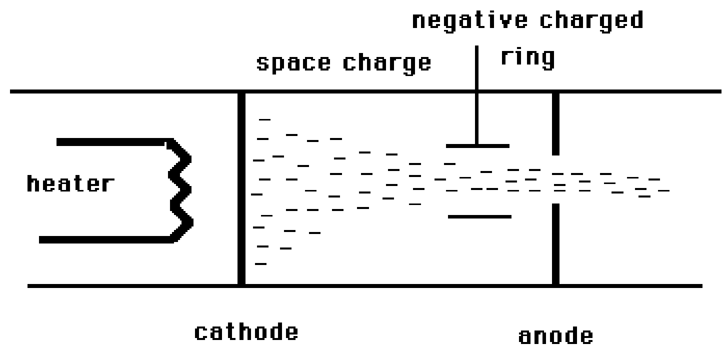
This device is a simplified version of a television tube that sends a beam of electrons (a cathode ray) from one end of the tube to another, striking a phosphorescent screen on the other end. In cross-section, the **CRT** appears as follows:



Parts of the **CRT** and their functions include the following:

The Electron Gun

At one end, an electron gun produces an electron beam, also called a *cathode ray* in the following way:
Charged parallel plates have an accelerating electric field between them. The negative plate may be called a *cathode*, the positive plate, an *anode*. If the cathode is heated to a high temperature, electrons will "boil" off its surface, creating a cloud of electrons (called a *space charge*) over the surface of the hot cathode. The electric field between anode and cathode will subsequently accelerate the electrons in the space charge towards the anode. If there is a hole in the anode, the electrons will not stop but pass through, creating an electron beam. All TV's and cathode ray tubes use this electron gun.

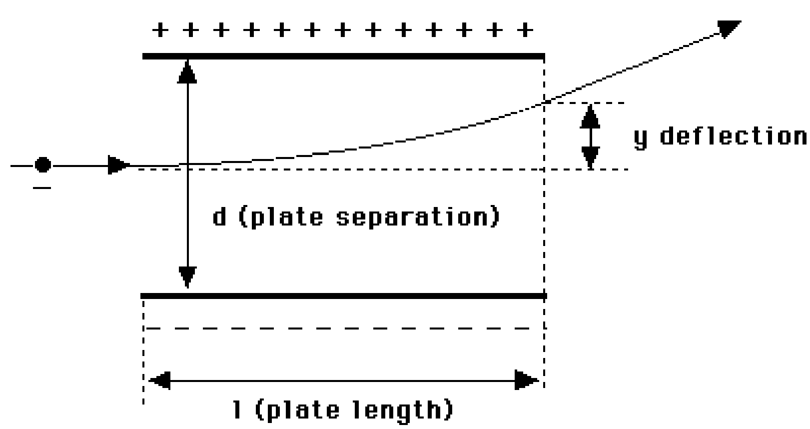


Between anode and cathode, potential energy is converted to kinetic energy so that

$$q\Delta V = \frac{1}{2}mv^2 \quad \text{---> which becomes} \quad v = \sqrt{\frac{2q\Delta V_a}{m}}$$

Note that ΔV_a stands for *accelerating* voltage, the voltage between cathode and anode in the electron gun.

Once through the anode hole, **v** remains constant until some other force acts on the beam of electrons. This force is caused by a second *deflecting* voltage ΔV_d acting on another set of plates, oriented so that the electrons are deflected up or down as they pass through the plates (similar to what you saw in the last section).



The last two sections explained how to solve relevant problems involving accelerating voltage plates and deflecting voltage plates. Also, a relationship between deflection d_y and the two voltages involved can be derived, and proven through experimental analysis to be

$$d_y = k\frac{\Delta V_d}{\Delta V_a} \rightarrow \text{be sure to memorize this relationship!}$$

Example 16. Given this information:

V_a = 100 V distance between Y-plates = 0.040 m

V_d = 10.0 V length of Y-plates = 0.100 m

a) use accelerating voltage V_a to find electron velocity in the x-direction v_x after leaving the anode.

b) since v_x is constant after leaving the anode, calculate the time taken for an electron to pass through the deflecting Y-plates.

c) use deflecting voltage V_d to find the force F_y on the electron between the Y-plates.

d) find the acceleration a_y of the electron between the Y-plates.

e) At this point, you have enough kinematics information to find the y-deflection d_y between the Y-plates.

f) If the accelerating voltage is now doubled, while the deflecting voltage is reduced to 3/4 of its original value, what is the new magnitude for d_y?

(see Electrostatics Ex 16 for answer)